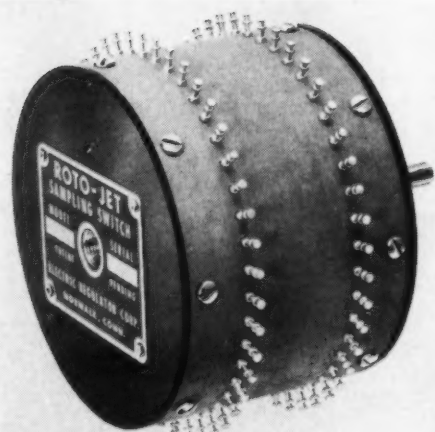
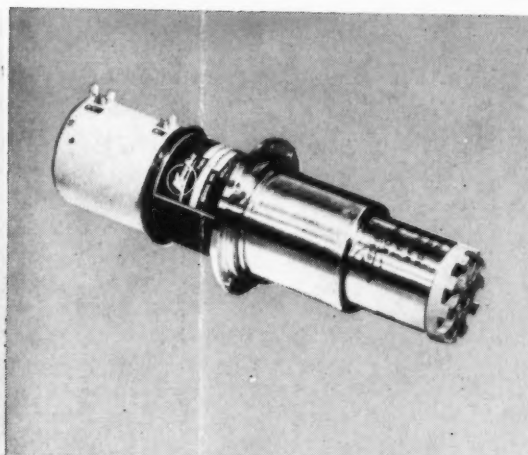


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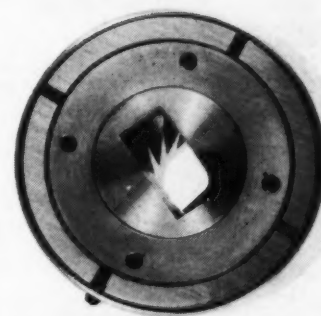
Military Systems Design



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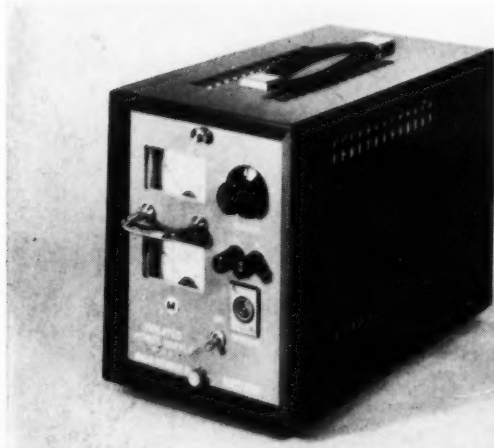


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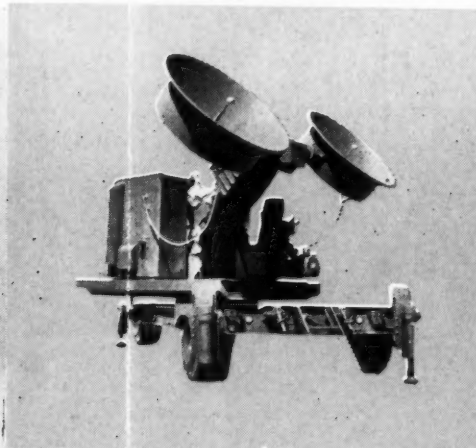


R. F. STEP-TWIST JOINT116

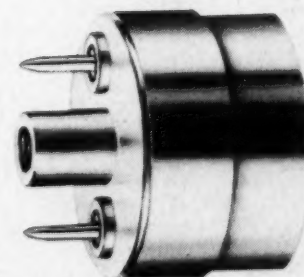
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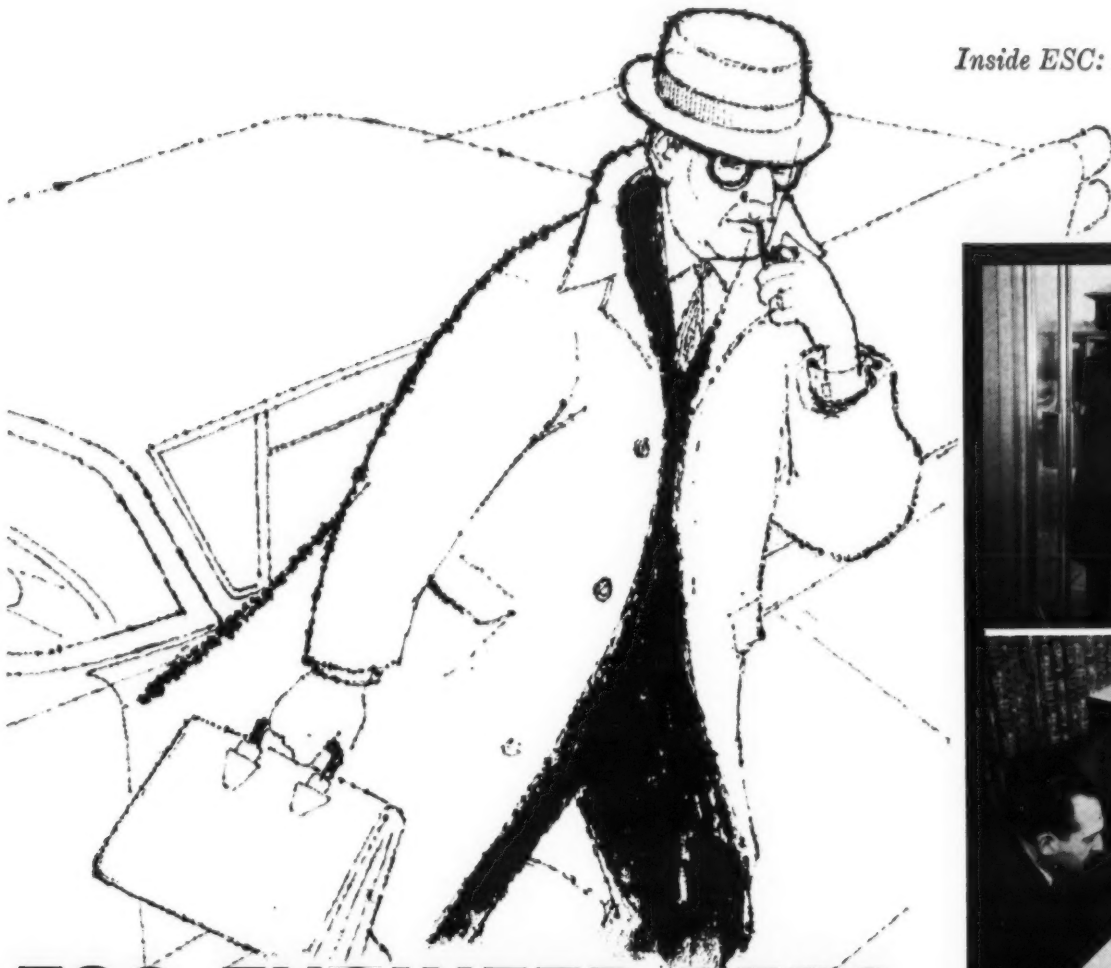


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Published bimonthly by Instruments Publishing Company, Inc., 845 Ridge Ave., Pittsburgh 12, Pa. Printed at 1600 N. Main St., Pontiac, Ill. Accepted as Controlled Circulation Publication at Pontiac, Illinois.

BPA

Richard Rimbach, Publisher

Claude O. Morrison, Editor
(Commander U.S. Naval Reserve)

Milton H. AronsonEditorial Director

Fred D. MartonAssociate Editor

Raymond C. E. SmithArt Director

David S. AlandProduction Manager

Main Office: 845 Ridge Ave, Pgh 12, Pa.
Fairfax 1-0161

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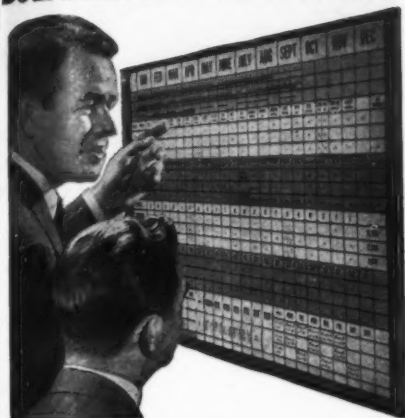
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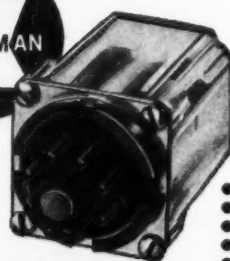
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formerly MILITARY AUTOMATION

Editorial

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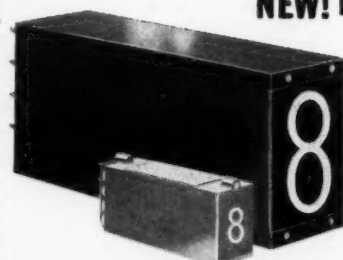
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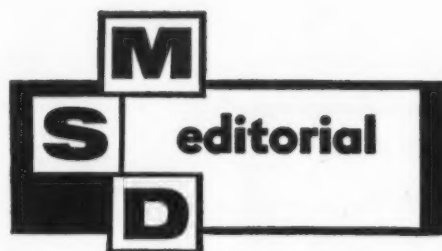


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Congratulations,

CONTINENTAL CLASSROOM

THE last twenty to thirty years have witnessed the marshalling of a great body of fundamental physical science, concerned with the basic constitution of matter. By incidental reading, as engineers, technical officers in the Armed Forces, or practicing scientists each within our own specialties, we have become more or less conversant with many of the concepts current in present-day nuclear, magnetic, and solid-state systems. Speaking personally, your editor has regretted that he could not afford the time to take a well-integrated graduate course in Physics designed to knit the many separate concepts so received piecemeal into one integrated pattern.

A letter from Colonel Nelson McKaig, USA-Ret, now teaching in the Junior College, St. Petersburg, Fla., mentioned that he was enjoying a course in Nuclear Physics over the local television station, and that the name of the program was "Continental Classroom." He stated that although it "met" at the unseasonable hour of 0630, 265 colleges and universities all over the United States are offering it for credit.

Following his suggestion, the program was locally "discovered" on NBC channel 11. It is sponsored for credit by University of Pittsburgh. The apparent disadvantage of the early hour is actually an advantage to concentration and regular attendance, because there are few competing distractions or appointments at this hour. Conducted by Dr. Harvey E. White of the University of California at Berkeley, with occasional guest lecturers, the course is a masterpiece of scientific teaching and a revelation in the educational power of television.

Dr. White expertly paces his lecture, proceeding slowly enough for the taking of essential notes. Attention of the learner is always focussed on the demonstration or the speaker, with a minimum of distraction. Closeup camera techniques provide enlarged displays of minute equipment details and split-screen photogra-



DR. JOHN F. BAXTER (right) offering the first color TV collegiate credit course, "Modern Chemistry," will appear on NBS-TV stations starting Sept. 28, 1959. The 160-lesson series will open daily at 6:00 AM with a kinescope re-run of "Atomic Age Physics" by Dr. White (left), followed at 6:30 AM by Dr. Baxter. 300 colleges and universities are expected to carry "Modern Chemistry" for credit.

phy is used to provide the viewer simultaneous meter readings, timer signals, etc. During experiments, the viewer takes readings from his own screen, which are plotted for verification at the next session.

For those wishing to receive graduate credit for use toward teacher accreditation, sponsoring colleges require payment of regular fees and require attendance at one Saturday session per month at the local sponsoring institution. Written problems are submitted to the sponsoring institution and returned corrected by the local coordinator. All responsibility for examinations and accreditation is thus handled locally.

Although ideally fitted for its primary purpose of upgrading High School science teachers, Continental Classroom is also recommended for any person who feels the need of a thorough recapitulation and review in modern concepts of atomic theory, nuclear physics, magnetism, spectroscopy, energy, and light. Dr. White's dignified and straightforward treatment engages and holds the viewer's interest through each half-hour session, Monday through Friday.

Continental Classroom, which recently won for NBC the Sylvania Distinguished Public Service Award, is sponsored by the American Association of Colleges for Teacher Education, Bell Telephone System, Ford Foundation, General Foods Fund, Fund for Advancement of Education, International Business Machines, Minnesota Mining and Manufacturing Co., Pittsburgh Plate Glass Foundation, United States Steel and Standard Oil of Calif., MILITARY SYSTEMS DESIGN extends its compliments to Continental Classroom and heartily endorses the further extension of modern science just announced. These courses will not only greatly improve the efficiency of present science teachers but should also assist in recruiting into the teaching profession many military officers now approaching retirement.

C. O. M.

MILITARY SYSTEMS DESIGN

Editor, MSD:

The caption under Fig. 1 of the article "Simulator Devices and Techniques are Varied," in the Jan-Feb issue of MILITARY SYSTEMS DESIGN indicates that it has the same target capacity of the older version in Fig. 2, although it appears to us to have only half the capabilities; that is, three controlled targets. Is this correct?

Marvin Slavin, Chief Engineer
Belock Instrument Corp.
College Point 56, N. Y.

We have referred this question to the manufacturer, who agrees that the caption supplied with the T2 picture was incorrect, and adds the following information: "The AN/SPS-T2 radar target generator as now constituted consists of (1) a 'master cabinet' which produces all signals common to all targets and which receives from and feeds to the radar switchboard; (2) two 'target cabinets' (only one was shown in the illustration), each containing 3-target capability, and (3) where required, a closely-regulated 250 va, 400 cps power supply. The equipment is also capable of producing up to 30 targets by the addition of target cabinets. The new equipment performs many functions other than target simulation, some of which cannot be discussed in context because of security regulations."

W. H. Paine, Mgr. Contract Admin.
Servonics, Inc.,
Alexandria, Va.

Editor, MSD:

In Figure 4 on page 11, 7th article, "Precision Trimmer Potentiometers", January-February issue of MILITARY SYSTEMS DESIGN, the curves are labeled in reverse of those shown on page 7-6 of the Technology Instrument Corporation Potentiometer Handbook. Which curves are correct?

R. W. Hart, Component Application Engineer
Collins Radio Co.
Cedar Rapids, Iowa

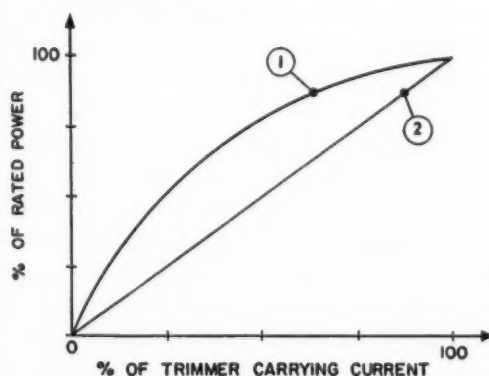
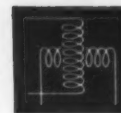


FIG. 4. POWER DERATING curves.

The author, Mr. Fred W. Aldrich, says the curves in the handbook are correct, and that the labeling of the curves in our illustration No. 4 should have read: "Curve 1, for metal housing; curve 2, for plastic housing".

Thank you, Mr. Hart, for bringing this to our attention.

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Computing Resolvers

Available with integral compensating windings. Can be provided with trimming networks to match existing isolation amplifiers or Kearfott-designed transistorized amplifiers.

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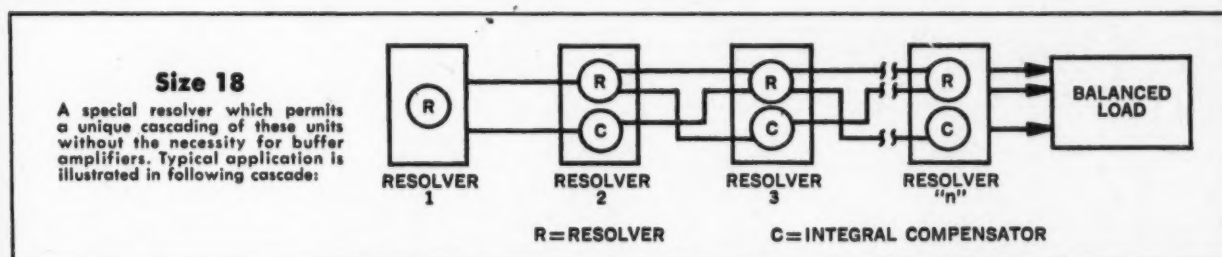
For applications where size and good functional accuracy are of paramount importance. Functional accuracy as good as 0.1% and bridge errors of 3 minutes of arc are in production.

Size 15

A 2:1 improvement in functional accuracy obtained in this configuration. Unit tabulated is the direct equivalent of standard Navy BuOrd Mark 4 Mod 3 and contains necessary trimming network for standard buffer amplifiers. Transformation ratio is 1.000 ± .0001, phase shift 0° ± 1 minute. Functional accuracy of .05% and bridge error of 3 minutes of arc are standard.

Size 25

For applications demanding the highest order of accuracy. Close attention has been paid to design parameters.



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	11		15	18	25
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Excitation Volts—(Max.)	60	60	26	26	115
Excitation Volts (Test)	10	10	15	13	25
Frequency—(cps)	400	400	400	400	400
Primary Impadance	629 + j2510	450 + j2200	220 + j1000	3000 + j (0 ± 40)	1630 / 78.5°
Secondary Impadance	695 + j2750	500 + j2300	240 + j1100	3000 + j (0 ± 40)	1620 / 80°
Transformation Ratio (Primary to Secondary)	.980	.980	.990	.775	.980
Transformation Ratio (Compensator to Rotor)	.985	.985	.950	.775	.985
Phase Shift (Lead)	8.5°	7.5°	8.5°	0° ± 10'	2.1°
Fundamental Null (MV)	15	15	8	15	15
Bridge Error From E.Z. (Max.)	*7 mins.	*5 mins.	*5 mins.	3 mins.	0.7 mins.
Primary	Stator	Stator	Stator	Stator	Stator

*Also available 3 mins. from E.Z.

Non-Compensated Resolvers

Basically for application in precise data transmission systems. These synchro resolvers permit system designer to achieve system errors of better than 1 minute of arc without using 2-speed servos and elaborate electronics. By proper impedance matches up to 64 resolver control transformers can also operate from one resolver transmitter.

Size 11

Where size is important. These units have a maximum unit error of 3 minutes of arc.

Size 25

Where highest accuracy is required. These units have a maximum error as low as 20 seconds of arc.

NON-COMPENSATED RESOLVERS FOR PRECISE DATA TRANSMISSION

	SIZE 11			SIZE 25		
Type Resolver	Transmitter	Differential	Control Transformer	Transmitter	Differential	Control Transformer
Part Number	R982-004	R982-002	R982-012	Z5161-001	Z5191-001	Z5151-003
Excitation Volts (Max.)	26	11.8	11.8	115	90	90
Frequency (cps)	400	400	400	400	400	400
Primary Impedance	170 / 77°	95 / 80.2°	2000 / 80°	400 / 82°	800 / 80°	8500 / 82°
Secondary Impedance	42 / 80.5°	110 / 75.7°	8000 / 76°	260 / 82°	900 / 80°	14000 / 82°
Transformation Ratio	.454	1.000	1.906	.7826	1.000	1.278
Max. Error from E.Z.	3 mins.	3 mins.	3 mins.	20 seconds	20 seconds	20 seconds
Primary	Rotor	Stator	Stator	Rotor	Stator	Stator

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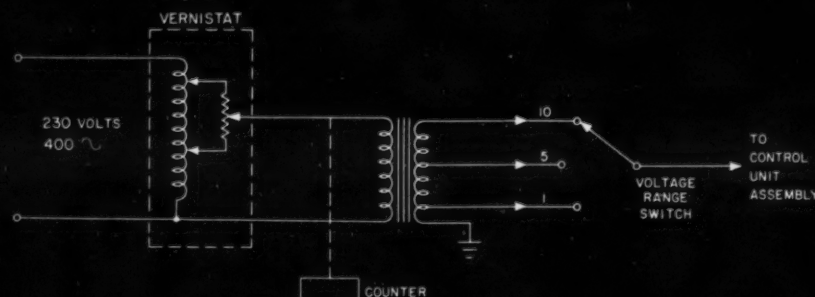
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Eclipse-Pioneer
designs test set
for B-58 Hustler
autopilot system...



An automatic flight control system that "thinks ahead" of the pilot is a "must" for the Air Force's Convair B-58 Hustler — world's fastest bomber. "Brain" of this system — developed by Eclipse-Pioneer Division of Bendix Aviation Corporation — is a compact control unit assembly in which all flight factors are continuously and instantly translated into commands to control surfaces. To check out this assembly quickly and conveniently, a mobile test set has also been designed — and Vernistat is there as an accurate source of test voltages in simulating a number of signals and commands.

...and
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is there!



Vernistat a.c. potentiometers were selected for several of the test panels because of their unique combination — in one component — of reliability, low output impedance, low phase shift, and high linearity. In the typical application above, a Vernistat is mechanically geared to a counter to provide an output voltage that can be accurately set to the required value. Low phase shift from input to output is maintained by the Vernistat's inherent design. And need for an isolation amplifier — with its added cost and disadvantages — is eliminated.

Doesn't Vernistat thinking belong in your system design too?

In this application, Vernistat thinking by Eclipse-Pioneer engineers helped solve a design problem with reduced equipment cost, system complexity, and design time. Cost was only a quarter of that of an alternative method utilizing conventional potentiometer, isolation amplifier, and d.c. power. Use of fewer components reduced system complexity, increased accuracy and reliability, and saved valuable

design engineering man-hours.

In servo systems, analog computers, and similar uses, you too can obtain such results with Vernistat a.c. potentiometers. With this new concept in relating shaft position to voltage, you get low output impedance (as low as 45 ohms) with high input impedance (as high as 200,000 ohms), plus high resolution (to 0.004%), low phase shift (as low as 0.2 minutes), and high

linearity (to 0.01%).

In addition to precision a.c. potentiometers, Vernistat products include function generators (adjustable non-linear potentiometers), and variable ratio transformers. Military specifications are met by the wide selection of models available.

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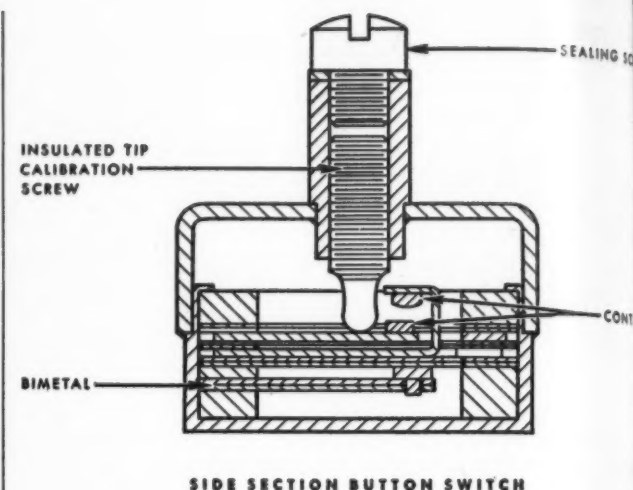


FIG. 1. NARROW TEMPERATURE differential and high repeatability requirements in miniature size were met in new Button Thermal Switch designed for military fire detection and overheat applications.

Button Thermal Sw

A BUTTON-SIZED thermal switch is being used with a new high-temperature technique to stabilize operation of electronic components where such equipment is exposed to a wide ambient temperature range. The problem of variation in operating characteristics of components resulting from temperature change has been around for a long time. More recently transistors have created their own set of problems regarding ambient temperatures. Since equipment for military uses in particular must operate under wide extremes of geography and altitude, maintaining 70°F ambient is often infeasible. A recent solution has been to design equipment for operation at 130°F, a temperature easier to maintain than 70°F because cooling is then accomplished using simple ventilation without cryogenics or refrigeration.

Control Products, Inc., Harrison, New Jersey, was asked to design a small bimetal thermal switch which could easily and conveniently be mounted in the small, odd spaces available in electronic and missile control units. Built-in characteristics of 1°F in temperature differential and repeatability were required. A calibration tolerance of 1°F for production units was further specified.

Their solution is the "Button" switch, with applications for precise temperature measurement of many

MILITARY SYSTEMS DESIGN

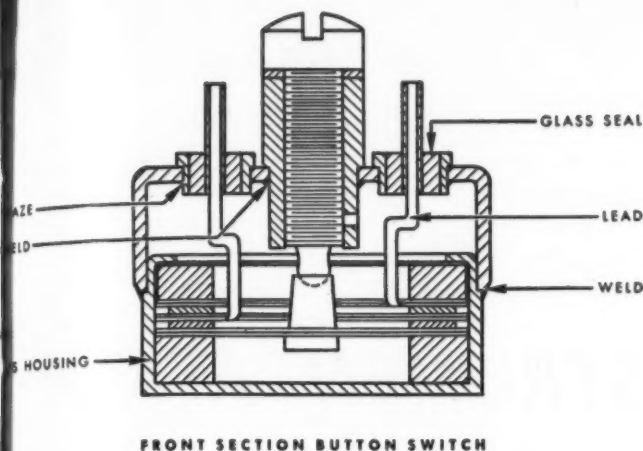


FIG. 2. HERMETICALLY SEALED construction and high temperature materials make the Button Thermal Switch at home in temperatures to 600°F, and immune to all environments.



FIG. 3. DISMANTLED BUTTON SWITCH shows high-strength bimetal element and husky construction throughout. Assembled unit compares in size with man's ring.

Switch Designed to Missile Specs

airborne and missile applications. Basically a bimetal thermal switch, it operates on the differential expansion principle as opposed to snap-action. The unit can be supplied with contacts for either close-on-rise (to start ventilation) or close-on-fall (to actuate heaters) (Fig. 1) and can be calibrated at any temperature from -20°F to 600°F.

This switch provides the very narrow temperature differential (difference between closing and opening temperatures) necessary for fire detection or overheat applications. The requirements for temperature differential and repeatability were met (1°F). Response time varies from very fast to delayed according to a number of factors involved in installation and application.

Its configuration, weight and size are the most significant physical features for military equipment designers. The switch can be mounted by lugs, soft soldered directly to or recessed into the surface to be controlled. Weighing 1/2 ounce, the lower portion of the switch is 3/4" in diameter and the upper portion is 25/32" to permit seating the unit in a recessed mounting. The overall height is 3/4" including the glass-sealed terminals and bushings (Fig. 2). The rugged construction of the bimetal element and contacts is shown in Fig. 3. Switch contacts are conservatively rated for 1 ampere resistive at 28v dc or 115 v ac.

Either factory calibrated or field adjustable switches are available. Both types are hermetically sealed. The housing is stainless steel with welded joints and brazed glass seals. No low temperature solder is used in the construction of the unit; so that the switch can tolerate either a momentary overshoot to 800°F or undershoot to -100°F.

Other Thermal Switches

The special characteristics for the Button switch answer certain particular military requirements. In this same area of minimal temperature differential switches, other switches offered by Control Products include a super-high-temperature line which can be calibrated up to 2200°F. Still other units can be calibrated as low as -50°F. A possible close temperature tolerance of 1°F. can be maintained for many units. For any given switch temperature differential and repeatability is about 1°F. Most of the line are either plug or probe types. One unit is hermetically sealed yet is field adjustable. All Control Products' thermal switches meet shock and vibration tests of MIL-E-5272A, Procedure I, and are available in plate or screw thread mounting, single or 2-wire construction. Contacts may be arranged for either close-on-rise or close-on-fall in temperature.

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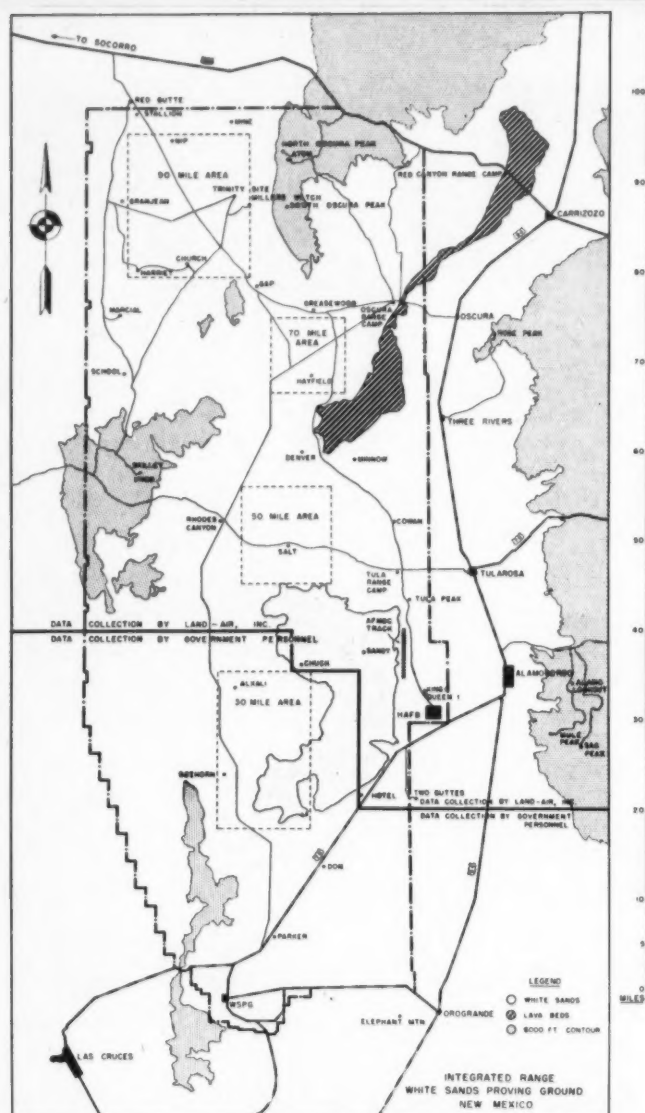


FIG. 1. INTEGRATED RANGE White Sands Proving Ground.

IN SOUTHERN New Mexico lies the largest inland missile testing area in the United States, the White Sands Missile Range, operated by the Department of the Army and used jointly by Army, Navy and Air Force agencies. This sprawling 4,000 square mile area (Fig. 1) located in a near-zero population density area called the Tularosa Basin, is bounded on the west and east by 9,000 to 10,000 foot mountain ranges. It encompasses the famous White Sands National Monument to the south, and to the north, the historic site of the first atomic bomb detonation. This New Mexico area is noted for excellent year around weather, a prime factor to be considered in missile testing with visibility averaging more than ten miles, 97 percent of the time. Unlike some other ranges, the excellent atmospheric conditions in this area are responsible for the extensive use of optical instrumentation devices to record missile flight data. The mountain ranges look down upon a desert plateau which provides a firing platform almost completely devoid of vegetation or other obstruction, furnishing a natural locale for instrumentation where flight of guided missiles can be effectively tracked, photographed and recorded from firing to impact.

The government-furnished test instrumentation facilities available at the White Sands Missile Range for missile flight testing and data collection are operated in the central and northern portions of the range by Land-Air, Inc., a civilian contractor employed by the Ordnance Corps of the Department of the Army. In the southern portion of the range, the instrumentation is operated by government (military and civilian) personnel. Land-Air, Inc., a pioneer company in missile range development and operation, has acquired over ten years' experience in the unique and specialized business of missile instrumentation at the White Sands Missile Range.

To accomplish this highly intricate business of tracking missiles, the personnel of Land-Air, Inc. operate what is probably the greatest concentration of optical and electronic tracking and data gathering devices ever assembled on a test range. The highly complex equipment used in this work includes optical systems, such as cinetheodolites, tracking telescopes and fixed cameras; electronic trajectory measuring systems, such as Miran, Dovap and reflection doppler radar; telemetry ground stations; a timing and communications complex; a complete photographic processing plant

and the necessary supporting activities such as a fleet of over 150 vehicles used for range transportation.

Missile Flight Phases

There are three major phases of any missile flight: Launch phase, mid-course phase and target or terminal phase. For each of these flight phases, the type of instrumentation used must be chosen to obtain the exact data required by the missile project. In general, fixed optical systems are used for launch data where performance must be measured with a high degree of precision. Under certain conditions, optical recording is supplemented by the use of CW Doppler type radar. For the mid-course phase where less precise measurements are required, instrumentation may be provided by one of the electronic trajectory systems or in conjunction with cinetheodolites and long focal-length objective telescopes. For the terminal or target phase, once again the need for exact measurements may arise. To meet this requirement, non-tracking optical instrumentation may be used when missile events can be accurately predicted; or, precision optical and electronic systems may be used to follow the missile and obtain data when the terminal phase may occur within

MISSILE RANGE INSTRUMENTATION

Robert Lovell

Land-Air, Inc.

Mr. Robert Lovell, Assistant Manager of Land-Air, Inc., as Director of Field Measurements, is responsible for test range instrumentation for about 75% of the White Sands Missile Range. Graduating in E. E. from the University of Michigan in 1943, Mr. Lovell served as shipboard Radar and Electronics Officer and Navigator. He currently holds the rank of LCDR in the Naval Reserve. He has been affiliated with Land-Air, Inc., since 1949, and has also served as research engineer with North American Aviation, Inc., at Holloman AFB, New Mexico. This article describes only those systems which are operated by Land-Air, Inc. at the White Sands Missile Range.

a larger area than can be economically or feasibly covered with fixed instrumentation.

Optical Instrumentation

The purpose of the optical instrumentation in use at the White Sands Missile Range is the photographic recording of missile performance. From these records, target position, velocity, acceleration, roll, pitch, yaw and chronology of events can be determined. Three general types of optical measurements systems—cinetheodolites, tracking telescopes and fixed cameras—are operated by Land-Air, Inc.

Cinetheodolites

The Askania Cinetheodolite (Fig. 2) is a precision position-measuring device which combines the functions of a theodolite with a sequence picture camera. These instruments photographically record the azimuth and elevation angles of the line of position from the station to the target. The position of the target is determined by combining the lines of position from two or more stations. Velocity and acceleration can then be derived from this position data. The basic equipment is manufactured in Germany and has been modified in this country to serve the specialized needs of missile instrumentation. Frame rates of five per second down to one per two seconds are available which give recording durations of from 3½ minutes to approximately 36 minutes. The frame rate to be used is dependent upon the length of flight to be covered and the frequency of data sampling required. Objectives used with these instruments range in size from 20 inches to 300 cm. A small missile approximately six inches in diameter and five feet in length and equipped with tracking aids can be recorded by the cinetheodolites at slant ranges up to 70,000 feet, while a medium sized aircraft can be recorded up to 25 miles. Thirty-three active cinetheodolite stations are presently being operated by Land-Air, Inc.

BRL-NGF High Speed Cinetheodolites have recently been introduced to the range to supplement the Askania Cinetheodolites. These instruments have recording rates to 40 frames per second and a longer focal length objective.

Acquisition Aids

As missiles go higher and faster, aids for acquisition for the tracking optical instrumentation become mandatory. These aids, either visual or electronic, make possible missile firings on days of marginal visibility and thus increase range scheduling effectiveness. Visual tracking aids in current use at the White Sands Missile Range include smoke, flares and fluorescent paints. A second method of acquisition, developed by the Signal Corps, is an electronic system in which the position of the target, provided by radar, is converted to voltages representing its position in a rectangular coordinate system. These voltages are coded and trans-

mitted on a radio link to the tracking stations where they are converted to azimuth and elevation values from the station to the target for display on center zero galvanometers. Center position on both galvanometers indicates to the tracking operator that his instrument is pointing directly at the target.

Tracking Telescopes

Tracking telescopes, often referred to as "attitude and event cameras", are used for a great number of purposes such as securing historical records of performance, intercept miss-distance, missile attitude, aspect and angle of attack, and any number of other items generally designated as attitude and event data. Telescope data is correlated with that produced by other systems by means of standard periodic and coded time signals generated by the range time standard. These instruments, equipped with long focal length objectives, may be used to cover the initial portion of a flight as well as being located along the flight line to cover the middle and terminal phases of the flight. The tracking telescope system operated by Land-Air, Inc. includes Turrets, Intercept Ground Optical Recorders (IGOR), and Terminal Trajectory Telescopes (TETRA).

The *Turret* tracking camera (Fig. 3) consists of a modified B-29 gun turret mounting a long focal length objective and using a Mitchell 35-mm High Speed Motion Picture camera for recording. The turret unit with the camera and objective is controlled directionally by a selsyn-servo system from signals furnished from a pedestal sighting station. The sighting station includes a sighting aid which is directed by the operator to follow objects at high tracking rates. A 40-inch objective is commonly used. The turret is tracked by one man and is capable of moving the camera and objective at higher angular rates than is possible with a hand-panned camera. The recording range of the turret is up to 10 miles on a 6 inch diameter missile and up to 25 miles on a large size aircraft. All turrets are trailer mounted for optimum portability.

The *IGOR* (Fig. 4) consists of a mount, a folded Newtonian reflecting telescope and a recording camera. The mount is modified from a US Navy 5-inch gun mount. The Newtonian optical system has a focal length of 96 inches and a 16-inch diameter primary mirror. A Mitchell 35-mm High Speed Motion Picture camera is used as the recording camera, while a Fastax camera can also be mounted to record thru the main objective or can be mounted below the objective with a 10 or 15 inch lens as an auxiliary recording system. Two tracking operators are required, one for azimuth and the other elevation. The IGORs are equipped to utilize the electronic acquisition data system in the same manner as the cinetheodolite equipment. Eight IGORs are operated by Land-Air, Inc. on the northern portion of the range. Recording range of the IGORs is 50 to 100% greater than the Turret.



FIG. 2. ASKANIA CINETHEODOLITE combines functions of a theodolite with those of sequence picture camera.



FIG. 3. TURRET TRACKING CAMERA consists of modified B-29 gun turret mounting a Mitchell 35-mm High Speed Motion Picture Camera with long focal-length objective.

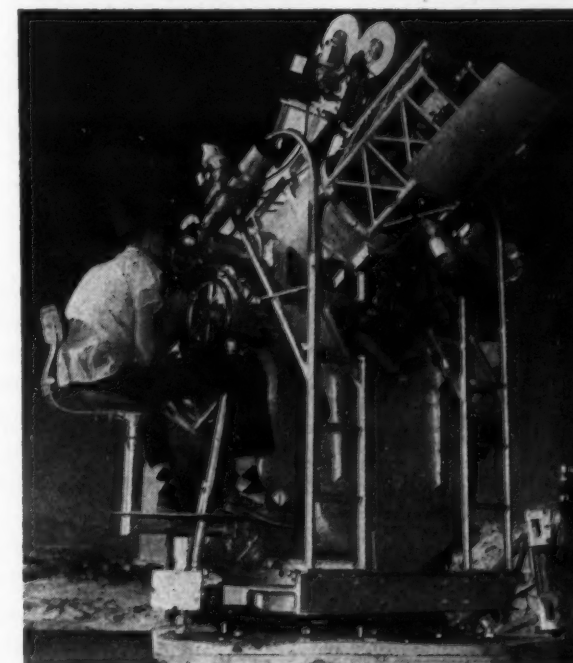


FIG. 4. IGOR (Intercept Ground Optical Recorder) utilizes modified Navy 5-inch gun mount with folded Newtonian reflecting telescope and uses both Mitchell 35-mm high speed and Fastax motion picture cameras.

Very similar to the IGOR instrument is the *Terminal Trajectory Telescope* (TETRA). This instrument (Fig. 5) is used to provide historical records, firing error indicator data in the form of vector miss-distance, missile attitude, aspect and angle of attack and rough (selsyn) trajectory data. It consists of a modified Navy 5-inch gun mount which mounts a folded Newtonian telescope of 84 inches focal length with an 18 inch primary mirror mounted on a tubular frame work. A 70-mm Mitchell High Speed Motion Picture camera with frame rate capabilities of 10 to 60 frames per second is used for recording. An auxiliary ultra-high-speed Fastax motion picture camera can also be mounted beneath the tube for simultaneous recording. Four TETRAs have been installed to date on the northern portion of the range.

Fixed Cameras

Several types of cameras are currently used as fixed cameras to record photographically missile trajectory and documentary data on the initial phases of ground launched missiles or the terminal phase just prior to impact. These include: Clark Ribbon Frame, RC-2 and CZR-1 Ribbon Frame and Ballistic Cameras used primarily for trajectory measurements; and the 1B and 5B Photosonic 70-mm Data Cameras, Mitchell 35-mm High Speed Motion Picture Camera and Fastax 16- and 35-mm Cameras, used to obtain event type data. These cameras are fixed mounted and oriented to cover a pre-determined portion of the missile trajectory. Using the Ribbon Frame cameras, the position of a missile is determined by combining lines of position from two or more cameras covering the same portion of the trajectory. Velocity and acceleration data are derived from the position data. Data from these cameras are more accurate than those obtained from other optical sources, because the cameras are fixed, installed closer to the flight path and record at a high frame-rate. Target boards are installed at the stations for reference markers and are so placed that the camera will view both the target boards and the missile trajectory. In addition to the Ribbon Frame cameras, used to obtain trajectory data on ground launched missiles, another source of precision position data for high altitude missiles are the Ballistic Cameras. These cameras have a wide field of view and record data on stable glass plates. In order to obtain data to the accuracy of which the cameras are capable, night operations are required; however, the system is not limited to night time usage.

Fixed Event cameras are frequently located in the vicinity of the missile launchers with a focal length objective chosen to record the desired events. Fastax cameras are used to record permanently for later study and analysis, phenomena too fast for the human eye to discern. Their high frame-rate stops motion, thereby magnifying space and time. The Mitchell cameras are also often used for documentary type coverage and provide lower recording rates, but better picture

quality than the Fastax cameras. Photosonic cameras are also available and produce picture quality comparable to the Mitchell cameras, but at frame rates up to 400 per second. The fixed cameras are often remotely controlled from a blockhouse or other safe area, since they are usually located close to the launching area.

Electronic Trajectory Systems

On the central and north portion of the White Sands Missile Range, Land-Air, Inc. has the responsibility for operation of five electronic trajectory measurement systems in support of missile tests. These systems are AN/MSQ-1 radar, Miss-Distance Indicator, Miran, Dovap and Velocimeter. Although basic range radar requirements are fulfilled by the Signal Corps chain radars which serve the entire proving ground, Land-Air, Inc. operates three AN/MSQ-1, S-band special purpose radars. These consist of modified SCR-584 radars with special computers. The characteristics of the system are classified. Also, an Anti-Aircraft Fire Control System (M-33) radar consisting of an X-band tracking radar, an S-band surveillance radar and a plotting-board van, is assigned to Land-Air for operational responsibility. It searches the area surrounding Holloman Air Force Base to report and plot positions of all aircraft on the range or threatening to penetrate the range.

The *Naval Ordnance Laboratory Miss-Distance Indicator* (NOL-MDI) system is used to measure miss-distance and relative velocity measurements on missile-drone intercepts. The system consists of a transponder in the drone, a telemetry transmitter in the missile, and a ground station. In operation, the FM transmitter in the missile emits a signal which is received by the drone transponder and the ground station. The signal received by the transponder differs from the signal transmitted from the missile by the amount of the Doppler frequency shift which is positive if the missile and drone are converging and negative if they are diverging. In the transponder, the received signal is beat against an internally generated signal. The difference frequency is then transmitted to the ground station. At the ground station, the drone and missile signals are mixed, fed through a discriminator and then recorded. "Quick look" data are available within minutes of the firing. This system provides a minimum miss-distance accuracy of ± 10 feet or 10%, whichever is greater.

MIRAN (Missile Ranging) is an omni-directional pulse time system for determining the position of a vehicle in space through triangulation between a master station, several slave stations and an airborne beacon. Miran data is recorded in three ways; as instantaneous trajectory plots from an analogue computer, by photography of range scopes showing loop ranges and through a digital computer which digitizes the range times, recording them on magnetic tape.

This system consists of five slave stations and one master recorder station and is capable of determining missile position over a range of 80 to 100 miles from the master station. Because omni-directional antennas are used, no tracking or following is required and acquisition is automatic and instantaneous.

DOVAP (Doppler Velocity and Position) is an omni-directional doppler system which provides accurate velocity, acceleration and position data of a missile in space. The system consists of ground station CW transmitters, ground recorder stations, a network of ground receiver stations, and an airborne beacon. In operation, the missile beacon receives the signal as transmitted from the ground station transmitter, doubles the frequency and retransmits. Ground receiver stations receive the signal from the missile and beat it against the first harmonic of the original signal received from the ground transmitter. The beat difference is the Doppler frequency; each beat means a change of radio path of one wavelength or about 6.6 feet. The data output of the system is collected at the recorder station in the form of oscilloscope presentations of the doppler output of each receiver station and is recorded photographically and on magnetic tape. Land-Air, Inc. has the responsibility for the operation of thirty-three receiver stations, two recorder stations and four transmitter stations within this system.

The *Velocimeter* (Fig. 6) is a CW directional S-band frequency system using the reflection radar principle to determine the radial velocity of a body at any precise moment in time. This equipment is used to provide radial velocity information with a high degree of accuracy, from launch to burnout, on ground launched missiles and rockets. The basic doppler radar as developed during WW II has been extensively modified to increase its capabilities to meet missile instrumentation needs. As used in the range instrumentation complex, the doppler output of the velocimeter is sent over wire lines to a mobile recording van where the data is recorded on magnetic tape. This tape may be played back through a tracking filter into an oscilloscope for photographic recording and subsequent data reduction.

Telemetry

To provide telemetry recording of in-flight data to missile contractors operating on the central and northern portion of the range, Land-Air, Inc. operates extensive ground recording, relay and check-out facilities. At the primary ground recording station, located approximately ten miles north of Holloman Air Force Base, four FM/FM ground stations (Fig. 7) are available, including three equipped for decommutation. Using all available recording media, 146 separate pieces of missile intelligence can be recorded at any one time. In addition to the FM/FM ground stations, a complete capability for recording both PDM/FM and PPM/FM telemetry is provided. To extend the

range of this primary station, both fixed and mobile relay stations are employed, the latter which may be located at any point on the range which has line of sight with the primary station. Four additional secondary recording stations are located throughout the range to provide complete coverage on missile flights regardless of where they occur and to enable simultaneous missions to be conducted.

At the FM/FM ground station which is the "work-house" of the system, the composite radio frequency signals from the missile are received and demodulated, leaving the complex RF sub-carrier frequencies. These are, in turn decommutated, if required, and the outputs fed to a patch panel for distribution to the recording oscillographs or to recorders which provide "quick-look" data. Provision is available for monitoring a number of pre-selected functions throughout the flight by missile testing personnel at one or more remote locations. The composite telemetry signal is also recorded directly onto high precision magnetic tape recorders, in addition to the recording of the sub-carriers and decommutated functions. Ground stations use specially constructed 6- or 7½-turn helix antennas which deliver an approximate forward gain of 8 db as compared with a standard dipole. The two principal telemetry systems in use at the White Sands Missile Range, FM/FM and PDM/FM, operate in the frequency spectrum 216-245 mc. This frequency spectrum is so widely used that all frequencies within the band are scheduled on a time-sharing basis. As an additional facility to expedite the missile contractor's pre-flight tests and to reduce "on the air" time, two complete closed-loop check-out vans have been made available. Each van houses a complete ground station and is independent of any outside support. These vans have been extremely useful in helping to relieve telemetry frequency congestion, thus permitting more range time for actual missile firings.

Timing

The analysis of missile flight data requires that collection instruments be controlled precisely with respect to time. These instruments fall generally into two categories—synchronized and free running. In the former, data points are taken simultaneously by a group of instruments. For this purpose, a synchronizing signal must be provided to all instruments on the system to control motor speed or shutter operation. With free running instruments, timing signals are recorded along with the data to provide correlation. Four timing generators, designed and built by Land-Air, Inc., are in operation on the White Sands Missile Range. Two are located in the central portion of the range and operated by Land-Air, Inc.; the others are located on the south portion of the range. The timing generators are all synchronized, and in addition, time signals may be "trunked" from either of the generators to the other, and "repeated" on the other's timing distribution system. Thus, data collected at any point on the



FIG. 5. TETRA (Terminal Trajectory Telescope) mounted on 5-inch gun mount similar to IGOR has wider field and accommodates Mitchell 70-mm high speed camera.

range may be referenced to a common time base.

The timing system is a decimal-weighted binary system providing periodic signals between 5000 cps and 1 cycle per 100,000 cycles plus several elapsed-time codes. The generator consists of a temperature-regulated crystal-controlled 100-kc oscillator standard and a train of 10 decade dividers. The frequency standard may be zero-beat against one of the assigned frequencies of Radio Station WWV, National Bureau of Standards. The long term (24 hour) accuracy of the frequency standard is 1 part in 10^6 . Short term accuracies, of 1 part in a 2×10^7 or better, may be realized. The 100-kc output of the frequency standard is divided to successively lower rates by means of decimal-weighted Eccles-Jordan binary dividers. Each divider provides the one-fifth, the one-half and the one-tenth rate of the input frequency to that particular divider.

A great variety of pulse rates, codes and combinations of periodic and code rates are possible from the signal generator. Timing pulses, in the form of rectangular voltage pulses one millisecond in duration, are amplified for wire transmission and are either fed directly to instrument stations or to redistribution stations where they are further amplified and distributed to stations in that area. All wire facilities are supplied by the Signal Corps, whether cable, pole lines or field wire. At the instrument stations, the bi-polar timing pulses are normally received on an amplifier, reshaped and separated by polarity into two separate sets of signals for operating or recording in the station equipment. Multi-channel radio facilities are also available for timing distribution to remote stations without wire facilities. For this purpose a 19-channel multiplex system is employed.

Communications

To support missile tests at the White Sands Missile Range through making possible the complete exchange



FIG. 6. VELOCIMETER is CW radar determining the radial velocity of any object at a precise moment in time. Output is sent over wire line to tape recording station.

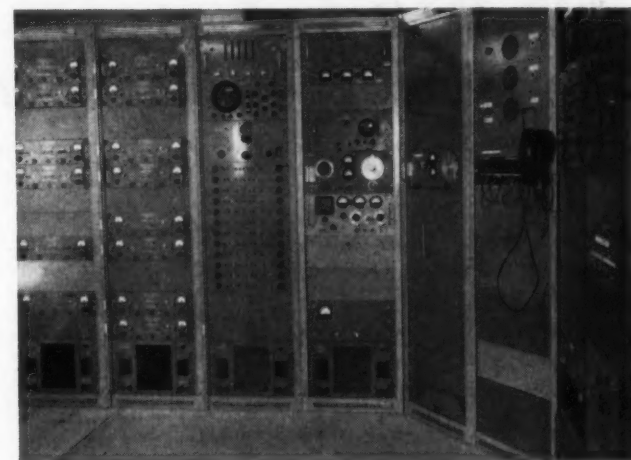


FIG. 7. TELEMETRY FM/FM equipment at one of four ground stations. Extensive magnetic tape recording facilities (not shown) are also available.

of information between the agencies conducting the test and the instrumentation involved, an extensive communication complex is required. This communication system consists of wire line intercoms, field telephones and radio links. Stations accessible to wire line facilities are equipped with loudspeaker intercom sets, while those beyond the reach of wire service utilize radio sets, working either directly with the control center or through an automatic repeater station located in the north range. The field telephone network is used primarily to provide communications between missile contractors and instrument stations for pre-mission check-outs. Additional and extensive communication facilities operated by Land-Air for specialized instrumentation purposes, include both mobile radio and ground-to-air communications, and microwave links used for both data transmission and communications.



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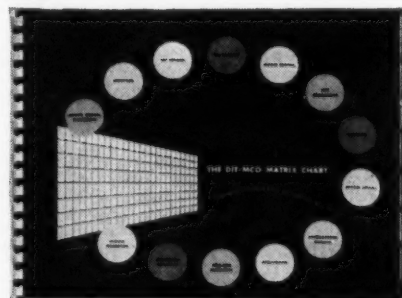
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Guidance Components for Space Probe Missiles

Precise control from launching to ultimate destination is the prime requirement for the successful achievement of missile objectives, including that of the space probe. One of the leading designers of precision electromechanical components for missile guidance, the Kearfott Company, Inc., of Clifton, N. J., has worked closely with the Army Ballistic Missile Agency (ABAMA) Redstone Arsenal, Alabama to standardize and improve both the guidance systems and their components through advance design con-

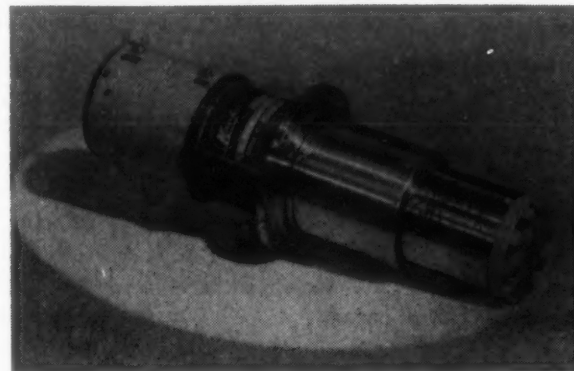


FIG. 1. SPECIAL COMPONENT combines motor generator, gearhead, potentiometer and slip-clutch in one package for improved operation and space-weight savings.

cepts and new fabrication techniques. This effort, coupled with the experience constantly accumulating in the fields of guidance, control, telemetering, tracking, computers and other missile and space vehicle components, has resulted in the utilization of a wide variety of Kearfott products in virtually every operational space vehicle administered by the U. S. Army Ordnance Missile Command, including the space probe.

The space-probe shots, Pioneer I through IV, have been accomplished under the sponsorship of the National Aeronautics and Space Administration, implemented by the scientists and facilities of Army's Ordnance Missile Command at Redstone Arsenal, Alabama. This cooperative arrangement, specified by the National Aeronautics and Space Act of 1958, has enabled the Redstone Missile team to make an impressive contribution to peaceful and scientific exploration of space at the same time that they have been functioning as a leading agency in the development of military missiles.

Although each of the earlier Pioneers were successful in returning valuable space data, the 13.4 lb Pioneer IV made history on 3 March 1958, when it became the first sun satellite to be launched by any of the free nations. It was tracked for 82 hours for a distance of 407,000 miles before its signals faded. Measurements of radiation in space were among the valuable data returned to earth via its three sub-carrier telemetry system.

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The Computer Handbook

edited by M. H. Aronson. A clear introduction to the entire field of electronic computers and data processors. Presentations by computer manufacturers at the Second Computer Clinic. Paperbound, 72 pages, 1956. \$2.00

Strain Gage Instrumentation

edited by Aronson and Nelson. "... a practical text... covers fundamentals, basic bridge circuits, typical applications, and surveys typical commercial instruments which use or are used with strain gages." Paper, 110 pages, illustrated, indexed by company, author, and subject, 1958. \$2.00

100 Electronic Circuits

by M. H. Aronson and C. F. Kezer... covers amplifiers, oscillators, pulse circuits, phase shifters, etc. Complete with all circuit component values and response specifications. Paper, 180 pages, 1957. \$2.00

Digital Techniques for Computation and Control

by Klein, Morgan and Aronson... all basic digital techniques within one text... code arithmetic, logical networks, multiplexing, conversion, data reduction, digital process control, two-terminal relay circuits, counting techniques, digital computers, programming, digital differential analyzers, and combined analog-digital equipments. Cloth, 394 pages, illustrated, 1958. \$6.00

A Romance in Research

The Life of C. F. Burgess by A. McQueen with Technical Appendix by O. W. Storey. Glimpses of the early days of radio talkies, television. Cloth, 430 pages, 1951. \$2.00

INSTRUMENTS PUBLISHING CO.

845 Ridge Ave., Pgh. 12, Pa.

For book list circle 11 on inquiry card.

MILITARY SYSTEMS DESIGN

For the space probe, Kearfott supplies standard and special equipment used in both the space vehicle's guidance system and its telemetering system, and in the ground support systems such as radar tracking and computing. Roughly 25 of these components are airborne, and each must be operationally perfect for ultimate success of the probe. About 30 others, meeting equally rigid requirements for perfection, are used in various ground support systems associated with the space probe.

One specially-designed component (Fig. 1) combined a motor-generator, gearhead, and slip-clutch with a potentiometer in one package for improved operation and a drastic reduction in space and weight over the method originally employed.

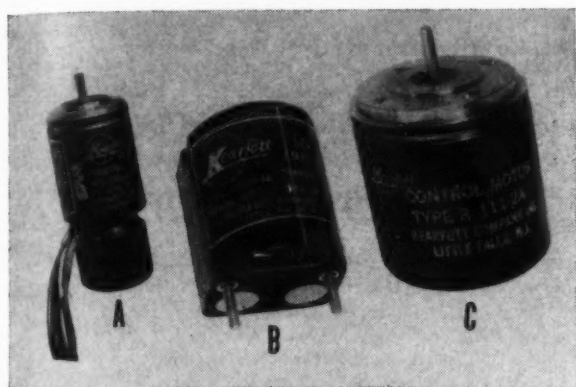


FIG. 2. TRANSISTORIZED AMPLIFIER is shown with typical servo motors it drives in missile control systems. (A) Size 11 inertially-damped servomotor. (B) 5-watt rugged transistorized amplifier. (C) Size 18, 115v 400cps servomotor.

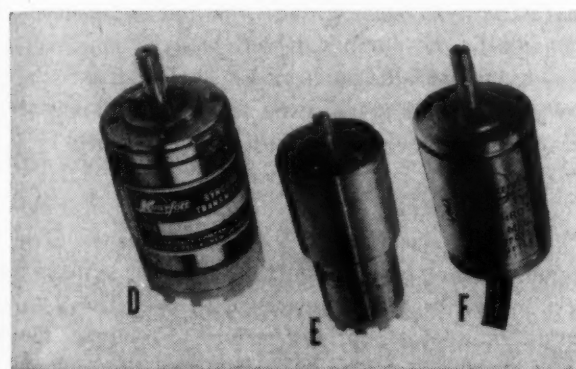


FIG. 3. HIGH ACCURACY SYNCHROS and motor-generator used in Space Probe Missile. (D) Size 11 high accuracy synchro control transmitter. (E) Size 11 servo motor-damping generator. (F) Size 8 "penny size" synchro control transformer.

A number of Size 18 and 11 servo motors are designed for operation from a 5 watt transistorized and completely potted servo amplifier (Fig. 2). The standard servo size number is roughly the diameter in tenths of an inch; e.g. Size 8 is only 0.750" dia. Other space probe units include miniature synchro units of high accuracy (Fig. 3) and damping servo motor-generators.

For more information circle 72 on inquiry card.

WITH THE FUTURE IN MIND



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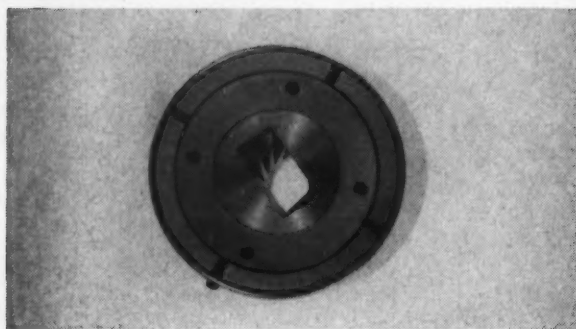


FIG. 1. ROTARY WAVEGUIDE joint for sector-scan antenna feed in the 16-17 kilomegacycle range permits free motion over a 180° arc while maintaining low VSWR and low torque.

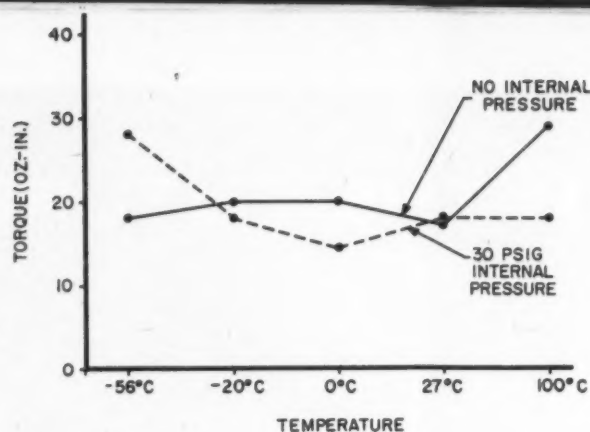


FIG. 2. MAXIMUM TORQUE required to rotate joint as a function of temperature and pressure. Maximum leakage at all temperatures was 1 cu-in per hr.; no torque change occurred with change in direction of rotation; and intermediate pressures produced intermediate torque values.

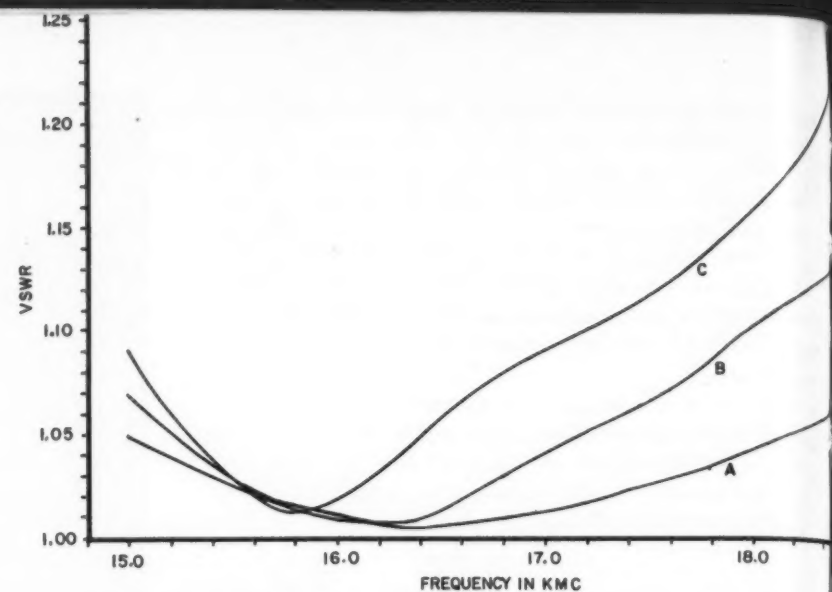


FIG. 3. TYPICAL VSWR readings of K_u Band Rotary Joint for (A) In-Line, (B) $\pm 60^\circ$ Twist and (C) $\pm 90^\circ$ Twist Positions.

K_u -Band Step Twist Joint

WILLIAM COHEN and CLINTON DEWITT
Senior Electrical Engineer Senior Mechanical Engineer

The electrical and mechanical design features of a high power, K_u band, pressurized waveguide sector-scan rotary joint applicable to airborne and missile-guidance radars are described. The unit discussed is capable of high power transmission with low SWR and WOW while being oscillated over a 180° arc. The assembly contains integral ball thrust bearings, pressure seals and a unique gearing system to control vertebrae positioning. The authors are staff members of Stavid Engineering, Inc., US Highway 22, Plainfield, N. J.

ROTARY WAVEGUIDE JOINTS are required in an airborne radar system to eliminate the necessity of having to mount the heavy transmitter on a rapidly moving gimbal system. The antenna pedestal design, therefore, requires the use of a rotary joint at each of the trunnion points. The prerequisites for good joint design to attain efficient electrical performance and maximum power transmission are low VSWR, minimum attenuation and minimum variation of VSWR (WOW) with angle. In addition, good mechanical performance of the gimbal-servo system requires that the rotary joint have long mechanical life and low torque characteristic while maintaining internal pressure.

In most cases the axes of airborne radar antennae are not required to rotate through a full 360°, thereby permitting the use of sector rotary joints.

Design Parameters

The Model LH3100 rotary joint discussed in this article is of the sector scan type designed to operate over an angle of 120° at scan rates up to 5 scans per second. The pedestal design dictated that the unit be as small as possible, preferably not more than 1 1/2 inches long or 2 inches in diameter, and to require a

minimum of driving force. The electrical design requirements for efficient transmission of energy, in the 16-17 kmc frequency range, dictated the dimensions of the vertebrae of which the joint is composed. The design center frequency was chosen at 16.5 kmc.

In addition, the maximum acceptable VSWR over the frequency range for the 120° scan was specified at no larger than 1:1.05. To provide this low VSWR the design must accomplish cancellation of the reflections due to the shifting of vertebrae as the joint rotates. Ideally, this is done by making the vertebrae thickness exactly 1/4 wavelength. The calculated wavelength of the wave in a guide at the design center frequency is 0.8743", and 1/4 wavelength is 0.2168". The final selected thickness of the vertebrae, 0.25", was a compromise between the ideal electrical length $\lambda_g/4$, and the mechanical considerations for proper tooth engagement of the vertebrae drive.

The Stavid Model LH3100 sector scan rotary joint consists of 12 basic parts. The inner and the outer housings are the largest of these parts and serve as the waveguide coupling flanges. Generally the outer housing is held stationary by the fixed waveguide to which it is fastened. The inner housing moves with the waveguide on the driven member. Inside these housings there are three short sections of waveguide

referred to as vertebrae. These sections move in the same direction as, and proportional to, the movement of the driven member. The angular movement of the inner housing is transmitted to the vertebrae through gearing. This gearing is so arranged that each of the vertebrae move to equally divide the housing displacement angle by the number of vertebrae in the assembly. Looking into the waveguide passage, it has the appearance of a short-step twist section, consisting of three vertebrae between the two housing sections (Fig. 1).

The entire assembly is sealed against leakage of the waveguide pressurization. The pressure seals limit the minimum torque values obtainable when the system is subject to an absolute pressure of 30 psi. The joint assembly incorporates thrust bearings to minimize the effect of the internal pressure. The maximum allowable torque specification of 30 oz-in was unattainable using commercial packings such as "O" rings, Quad rings and Teflon "O" rings. The final design incorporates a synthetic rubber chevron seal. With this type of seal, unpressurized, 8 oz-in of torque are required to rotate the joint. The increase of torque attributable to the pressure is approximately 4 oz-in. These values vary somewhat from seal to seal and from assembly to assembly. The maximum torque values required to rotate the joint through a 180° arc are in the range of 30 oz-in for a pressurized assembly over an ambient range of -56°C to 100°C as may be seen from Figure No. 2.

Life tests consisting of 160,000 cycles of operation

over 180° arc have been made. Examination of the parts after the tests reveals that a life expectancy of two million cycles can be easily obtained.

Electrical Performance

Electrical measurements on a pilot run of these joints have vindicated the mechanical compromises made in the design of the joint. The joint has been tested with the maximum peak power levels obtainable from currently available K_u band magnetrons. No discernible attenuation or discontinuities were observed when the assembly was rotated over its maximum range under full power. Typical VSWR curves as a function of frequency are shown in Fig. 3, for vertebrae rotations of 0°, $\pm 60^\circ$ and $\pm 90^\circ$, respectively. The curves show that the required VSWR was obtained over the desired bandwidth, 16-17 kmc, for 120° ($\pm 60^\circ$) rotation. It is interesting to note that for 180° ($\pm 90^\circ$ rotation, where the reflections are the worst, the minimum VSWR occurs more nearly at the frequency whose $\lambda_g/4 = 0.25$ inches. These curves indicate that by proper selection of the vertebrae thickness a sector scan rotary joint can be designed at any frequency with a VSWR of 1:1.05 over a 6% bandwidth, permitting a full 180° rotation.

For more information circle 73 on inquiry card.

Piezoelectric Ceramics

Piezoelectric crystals, such as quartz, have been used in electronic components for many years. However, because of their single-crystal form, their applications have been limited to small simple shapes. The development of polycrystalline ceramics such as barium titanate and lead titanate zirconate, on the other hand, can be fabricated into piezoelectric elements of almost any shape desired, using conventional ceramic techniques.

Properties of three barium titanate piezoelectric materials and the new high-temperature high-stability lead titanate zirconate ceramic, C43 A, which are produced by the Sprague Electric Co., are shown in the table below. The materials also exhibit a minimum piezoelectric constant of 10^{-15} coulombs/dyne, a maximum dissipation factor of 2% at 1kc, and a minimum compressive strength of 50,000 psi.

Properties of SPRAGUE PIEZOELECTRIC CERAMICS

	Barium Titanate		Lead Titanate Zirconate
	C15, C39	C37	C43A
Ceramic Type	C15, C39	C37	C43A
Dielectric Constant (1kc)	1100	1100	450
Max Operating Temp.	115°C	100°C	330°C
Density	5.6	5.5	7.6

Sprague Electric Co. also makes complete transducer assemblies for most applications including underwater sound, accelerometers, and squib fuze actuators. Engineering assistance in the use of their piezoelectric ceramics will also be furnished on request.—(From 2-page Engineering Bulletin No. 6900, Sprague Electric Co., North Adams, Mass.)

For this literature circle 74 on inquiry card.



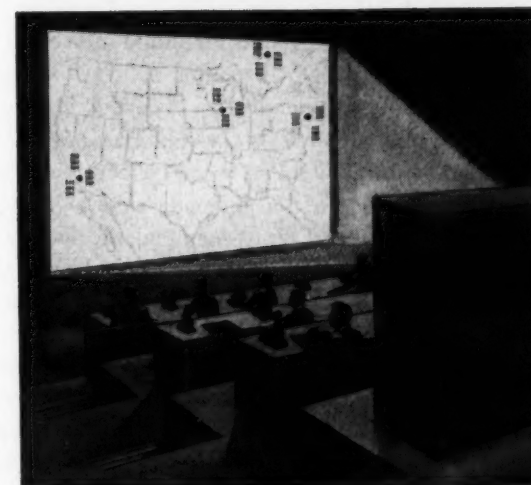
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See the S-C 2000 Bright Display demonstrator at the AFCEA Show, June 3-5, Washington, D.C.—Booth 89.

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STROMBERG-CARLSON DIVISION

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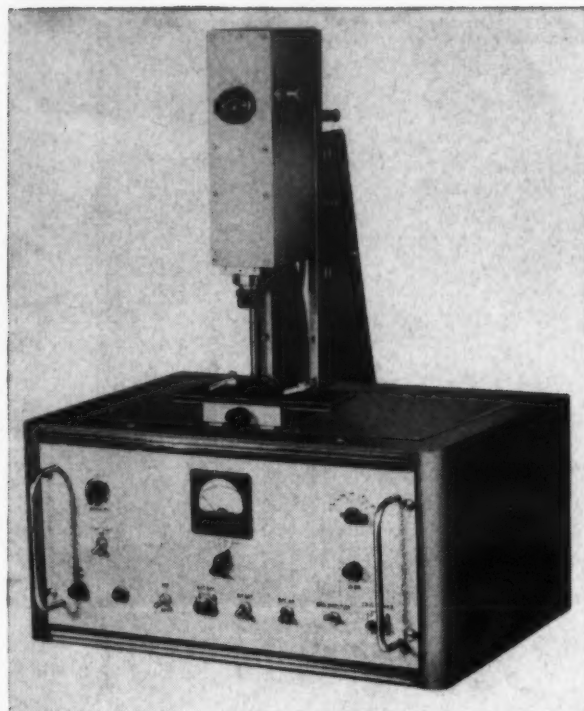


FIG. 1. SEMICONDUCTOR figure of merit is minority carrier life-time measured to micro-second accuracy.

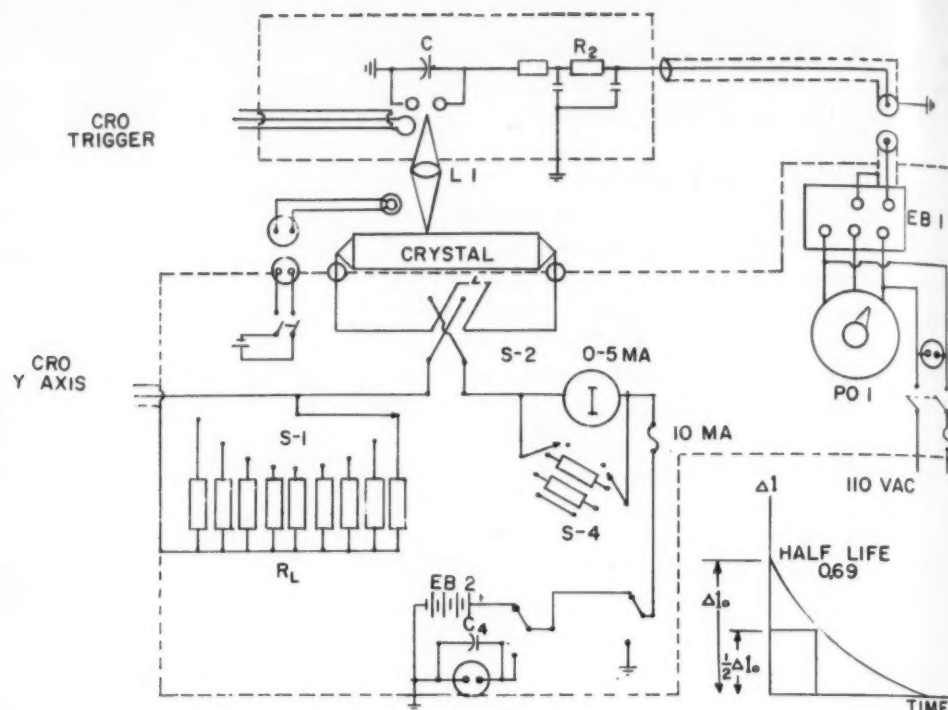


FIG. 2. ARC-ACTIVATED crystal experiences transient decay of photoconductivity, as shown in exponential curve (inset).

Semiconductor Minority Carrier Lifetime Measurements

by Engineering Dept.
Electro Impulse Lab., Inc.

THE theory of conduction of electricity in semiconductors is based on a two carrier model: that is, there are two types of mobile charge carriers, namely, electrons and holes. In an intrinsic semiconductor, the concentration of free electrons and holes are equal, and, because of the requirement of charge neutrality, the number of bound, or immobile charged ions are essentially nil. On the other hand, in an extrinsic, or impurity semiconductor, the concentration of one of the mobile charges predominates. Hence, there must be approximately an equal concentration of immobile charged ions of the opposite sign to satisfy the neutrality condition. For example, in intrinsic germanium at room temperature there are approximately 3×10^{13} carriers per cubic centimeter of each sign. An impurity sample of germanium containing 10^{15} donors and much fewer acceptors would have concentrations of approximately 10^{15} free electrons, 10^{15} bound positive donor ions and 9×10^{11} free holes. If donor and acceptor concentrations are reversed, the hole and electron concentrations become reversed.

The concentrations of carriers and charged ions are in thermodynamic equilibrium, brought about by the generation and recombination of hole and electron pairs, electron and donor ions, and hole and acceptor

ions. In the equilibrium state, the generation process is a thermal "evaporation" process in which thermal agitation of the lattice "boils off" the charge carriers. In the reverse process, recombination, electrostatic forces are involved which cause capture (or condensation) of the oppositely charged entities.

The non-equilibrium state exists when an excess or a deficiency of any of the paired charged entities exists. At present, for practical devices, the electron-hole pair excess or deficiency is the state of principal interest. Excess electron-hole pairs can be generated by optical radiation, corpuscular (principally electrons) radiation, and by current injection at a rectifying contact, biased in the forward direction. If injection takes place at a steady rate, such as that resulting from the constant irradiation of an incandescent lamp, or from that resulting from a steady d.c. current flowing from a rectifying contact, then the concentration of excess electron-hole pairs will reach a constant value in time at each point in the material, but decreasing in value with increased distance from the sources of injection. If the injection is transient, such as that produced by a pulse of light, then the excess pairs will recombine to restore the equilibrium concentration. The average survival time of this excess concentration of electron-hole pairs is termed the minority-carrier lifetime of the sample.

The importance of minority carrier lifetimes, measured in microseconds, is that they provide the figure of merit by which semiconductor materials may be

judged; i.e., the longer the lifetime, other characteristics being equal, the better the transistor or diode the material will make.

Recombination takes place both in the bulk and at the surface of the material, and in general at different rates. For low level injection, except in the presence of trapping, the decay (rate of recombination) is usually always exponential. Even with trapping the decay is usually rendered exponential by filling the traps with excess carriers generated by steady illumination of adequate intensity.

Life Time Measurement

The measurement of lifetime by the decay of the photoconductivity is based on the transient decay of the carriers. Green¹ gives the following equation for the transient photoconductivity current resulting from a plus of injected carriers for the case of one-dimensional geometry:

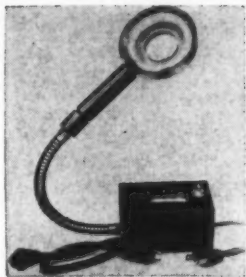
$$\Delta I = (1 + b)/R_c \int_0^d \Delta p / (n_0 b + p_0) E dx \quad (1)$$

Where R_c is the total series resistance of the circuit, b the mobility ratio of carriers, Δp the concentration of injected electron-hole pairs, n_0 and p_0 the steady state concentration of electrons and holes, respectively, and E the electric field. The integral is taken over the length of the semiconductor. In practice, the condition of absolute one dimensionality is difficult to obtain; however, Green gives an equivalent circuit showing that the transient current flowing in a series resistor external to the semiconductor is proportional to the quantity on the right of equation (1), except that the

¹M. Green, J. Appl. Phys. Vol. 28 1473-1478 (1957).

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Mic-O-Lite is a cold light ring source designed especially to produce "shadowless" illumination on small objects, parts or specimens. It is an ideal source for visual inspection under magnification, but is primarily designed for low power microscopic inspection and photography in the industrial, scientific and research fields.

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A variety of interchangeable lamps including warm white, daylight white, blue, "Black Light" and germicidal are available.

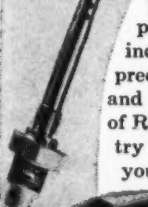
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For more information circle 15 on inquiry card.
May-June, 1959

effective resistance R_c is greater than the total series circuit resistance R_e . The latter circuit applies to a parallelepiped or a right cylinder with axial current flow.

If the specimen to be measured is uniform both resistivity wise and geometrically wise in cross-section, then the quantities E and $n_0 b + p_0$ will be only constant

multipliers so that the integral $\int_0^d \Delta p dx$ gives the total

excess injected pair concentration. Hence, since the transient current is proportional to this quantity, it must vary in time with it, thus providing the decay² pattern of the carriers. In general, the transient current ΔI shows an exponential decay.

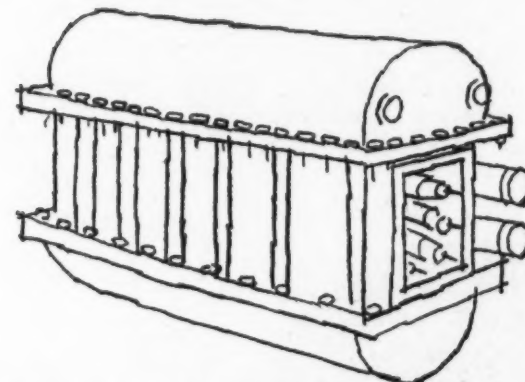
There are very few commercially available, completely self-contained instruments for measuring lifetime. Electro-Impulse Laboratory, Inc., Red Bank, N. J. is one of the few instrument companies that provides such an instrument (Fig. 1) which requires only a high quality oscilloscope for complete operation. This instrument has been designed to measure lifetimes as short as one microsecond and to accommodate large and small samples, including cylindrical ingots. A schematic diagram of the instrument is shown in Figure 2. The noninductive capacitor C is charged through the 10 megohm resistor R_2 by the variable high voltage power supply E_{b1} to the firing voltage of the air gap between two tungsten electrodes. The resulting light flash is focused by the lens L_1 onto the sample. A signal proportional to ΔI is generated across R_L and displayed on a cathode ray oscilloscope.

The chief advantage of the condensed spark as a means of injection is that it achieves a high injection (about 10^{12} — 10^{13} pairs) in one microsecond. This makes the lifetime measurement possible under more severe conditions, such as the measurement of short lifetimes in low resistivity materials, the measurement on a noisy sample, and the measurements of lifetime on fairly large specimens, should this be desired. In addition, the high light intensity of the spark is useful as a fast method to test metal-to-semiconductor contacts for rectification; the degree of rectification is indicated by the magnitude of the photo voltage generated at the contact. It is also very useful for probing the specimen for uniformity, since a variation in resistivity along the specimen gives a corresponding variation in the peak transient current ΔI , equation (1), when the light spot is moved along the crystal. In fact, equation (1) shows that ΔI varies as the square of the resistivity for constant current density. Another use of the instrument is the measurement of drift mobility of minority carriers as described in reference 1.

²Provided the carriers are injected sufficiently far away from the electrode at which minority charge carriers are swept out of the specimen, i.e. they must "die" within the specimen.

For more information circle 75 on inquiry card.

A PROBLEM OF UTMOST GRAVITY



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Weight, in one form or another, seems to be a concern of most of us today. While astronauts contend with the problem of "none at all", designers of electronic components continually face the problem of "too much".

An aircraft manufacturer recently called on Raytheon to design a 10,000-volt, 60-kva, 400-cycle, filtered DC magnetron power supply for high-temperature airborne-radar application. Several designs were available, but their weight -- more than 1,800 pounds -- put them in the lead balloon class.

Our engineers, thoroughly experienced in the field of fluorochemical transformer design, were able to get the "lead" out, about 1,300 pounds of it, and to come up with a unit (shown above) weighing less than 500 pounds.



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Light-Weight Circulator Tees

The well-known, but hitherto little used, ferrite resonant post technique is employed by the Kearfott Company, Inc., Microwave Div., of Van Nuys, Calif., in its new lightweight, compact Circulator Tee devices which are said to have an exceptionally low insertion loss with a high isolation ratio. The device depends on the property of a resonant ferrite post, located within a waveguide and under a transverse dc magnetic field, to unidirectionally affect microwaves within a limited band.

Adaptable for narrow band (X or K_u), and with peak powers up to 1 kw, the new components are simple in design and entirely self-contained. This simplicity aids in reducing the overall system size, making the new units ideal for use in missiles, rockets and other small size microwave systems. One component of the new series is the Model W117-2A-1 Circulator Tee, Fig. 1.

Another typical Circulator Tee, the Kearfott Model 117-3A-1 Iso-Duplexer, is shown in Fig. 2. Its test performance at 9.3 kmc $\pm 4\%$ is shown graphically in the curves of Fig. 3, with (a) isolation between arms I-III—15 db min, I-II—20 db min; (b) insertion loss I-II is 1.0 db max, II-III 0.6 db max; and (c) VSWR in arm I is 1.51:1 max, arm II, 1.6:1 max. It is 3 $\frac{5}{8}$ " long, 2 $\frac{1}{8}$ " wide and 2 $\frac{5}{8}$ " high, weighs less than a pound.

The new Tee Circulators are readily adaptable to other configurations: Replacing the permanent magnet with electromagnet provides a fast-acting switch or modulator; additional isolation between specific arms can be provided by adding built-in ferrite sections, or a fourth port can be added for introducing a second signal input or other special needs. Also, models for other bands are available.

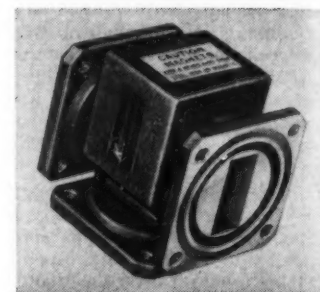


FIG. 1. MINIATURE CIRCULATOR TEE for missile and rocket microwave systems uses ferrite resonant post to achieve high isolation with low insertion loss.

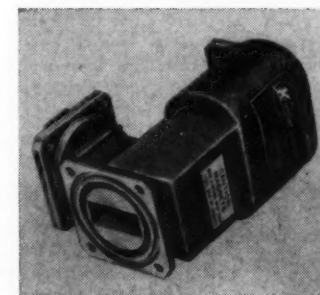


FIG. 2. ISO-DUPLEXER TEE is also available in the miniature Circulator Tee line.

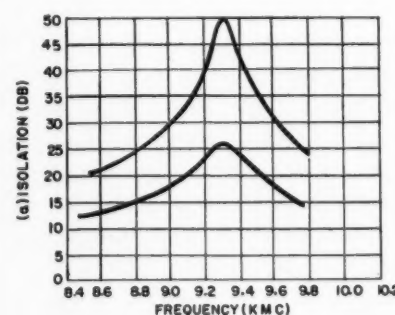
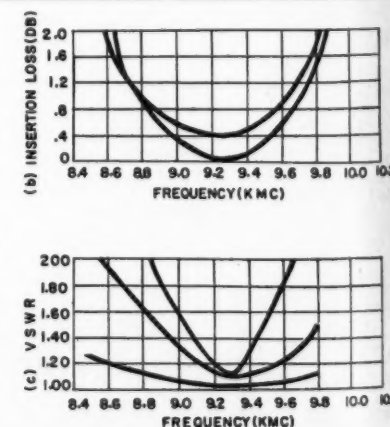


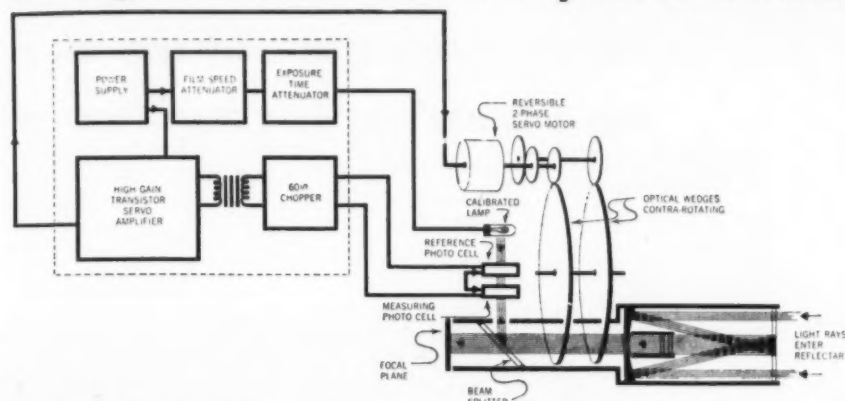
FIG. 3. TEST CHARACTERISTICS of Kearfott Iso - Duplexer Model W117-3A-1 include: (a) Isolation in db, (b) isolation loss in db and (c) VSWR plotted against frequency.



For more information circle 76 on inquiry card.

MILITARY SYSTEMS DESIGN

Through-Lens Automatic Exposure Control



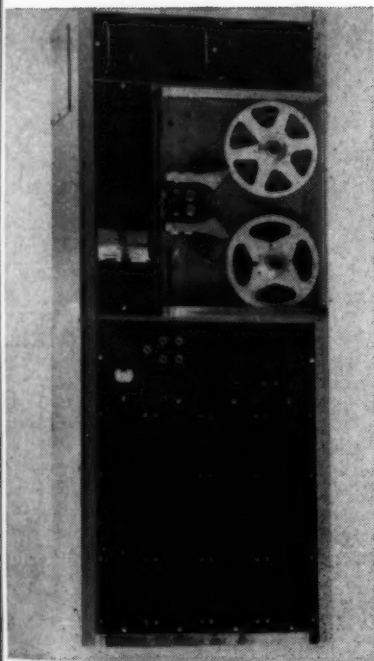
Missile range cameras, theodolites and tracking telescopes can now be equipped with through-the-lens automatic exposure control which requires no additional optics. Designated the Zoomar-Trulex Automatic Exposure Control by its developers, it compensates for excess illumination by two counter-rotating optical wedge discs.

A beam splitter, which absorbs only 8% of

the main light flux, works through a transistor amplifier and a feedback servomechanism to achieve a control range of seven f-stops. It requires only $2\frac{1}{2}$ " between lens and camera; can be delivered as an integral part of any Zoomar-Reflectar Assembly with a focal length of 6" or more. (From data sheet, Zoomar-Trulex, Zoomar, Inc., Glen Cove, L. I., N. Y.)

For more information circle 77 on inquiry card.

Data Recorder Features Accuracy



DATA RECORDER prepares FLAC data—provides two optional accuracy checks.

The development of a new high-speed Data Recorder which features high data reliability, to be used in conjunction with radar tracking stations at Patrick Air Force Base and at strategic islands along the 6,000 mile Atlas missile tracking range, has just been announced by Technitrol Engineering Co., Philadelphia manufacturer of computer components and systems. The new Data Recorder (See Figure) is designed to automatically store radar information such as Azimuth, Elevation and Range on magnetic tape in either coded decimal or coded binary form for future input to the Florida Automatic Computer (FLAC) for data reduction and analysis.

One of the unique features of the Data Recorder is that in addition to the normal recording process, it is designed to automatically check the complete information written on the tape for accuracy by either of two techniques. One method, which is designated Pre-Flight Mode, compares the information that was inserted into the shift or buffer registers from the radar equipment with what was written on the tape (In either of the two check modes, the registers' outputs are non-destructive). The other method, designated Pre-Flight/Simulate Mode, compares the information on the tape against a sequence of switches which are located in the recorder and which enter a binary code into the storage registers.

Using either technique, the information in the storage registers is interrogated, but not however, shifted out of the registers. If the comparison logic detects a dissimilarity between the two sources, an error pulse stops the Data Recorder at the end of the block being checked and an indicator light denotes the storage buffer and the bit number of information that was in disagreement.

The self-checking feature of the Data Recorder was incorporated to help increase the reliability of missile flight data, and it imposed the biggest design problem to overcome during the recorder development stage.

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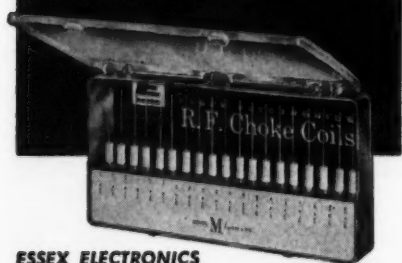
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122

Janus Doppler Navigation System

Air Navigation Instrument capabilities are ably illustrated in a new coherent, high-performance FMCW Doppler Radar System, Collins Model DN-101, now being evaluated by airlines and which employs many techniques which have been used previously in classi-

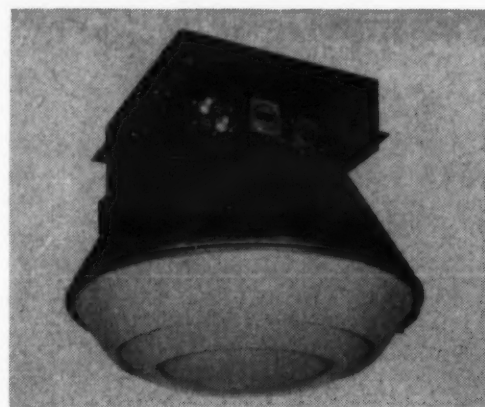


FIG. 1. ANTENNA OF COLLINS DN-101 Doppler Radar System mounts near the center-line of the aircraft. The system directs three separate beams of X-band energy diagonally toward earth, then accurately measures frequency shift in each beam between transmitted and reflected signals.

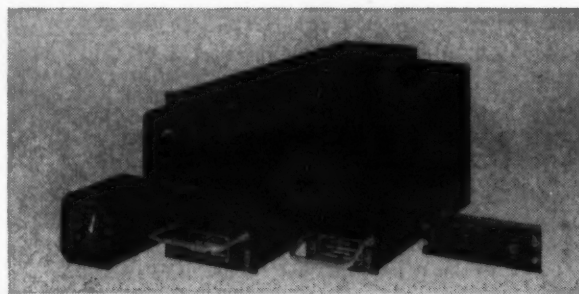


FIG. 2. INBOARD COMPONENTS of Collins FMCW Doppler System from left to right: Cockpit Indicator for Ground Speed and Drift Angle; Computer-tracker; Transmitter-receiver and Remote Control Unit.

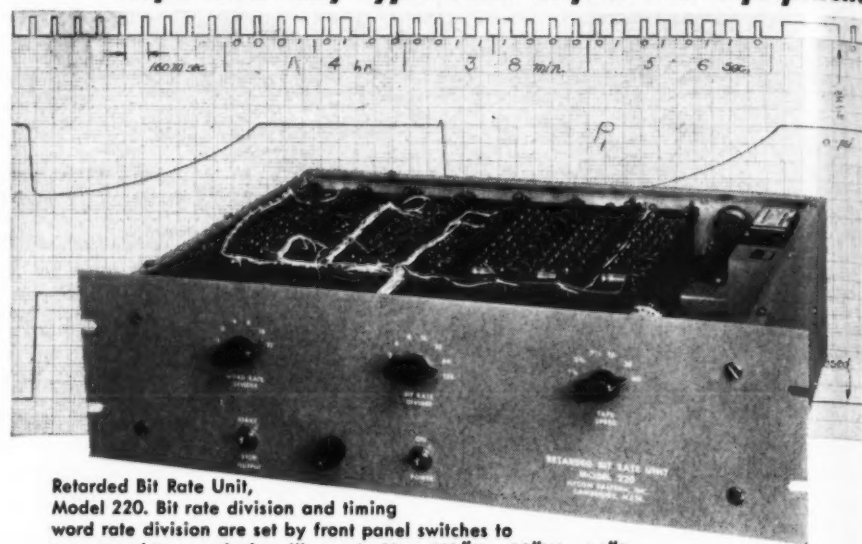
fied military aircraft applications. Using the same principles of FMCW radar employed by FM radar altimeters as early as World-War II, but highly refined, the new system weighs less than 60 lbs and requires only 200 watts power for operation.

The Janus (two-way looking) technique of Doppler operation uses three radar beams, one on each bow and one to the left astern. Doppler frequency-shift information from each beam is fed into a computer/tracker which provides ground speed and drift angle indications from 0 to over 50,000 ft altitude while automatically compensating for aircraft pitch, roll and vertical velocity errors.

The antenna is a fixed lens, horn fed type without active circuits. By using crossed linear polarization in the feed horns, two navigation systems may be fed through the one lens for maximum reliability. Ex-

New RETARDED BIT RATE UNIT

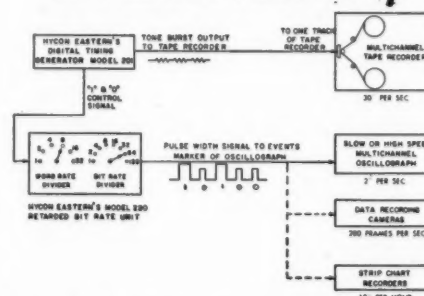
provides simultaneous indexing of magnetic tape with any type data acquisition equipment



Retarded Bit Rate Unit, Model 220. Bit rate division and timing word rate division are set by front panel switches to correspond to speed of oscillograph. Size: 5 1/4" H x 19" W x 16" D.

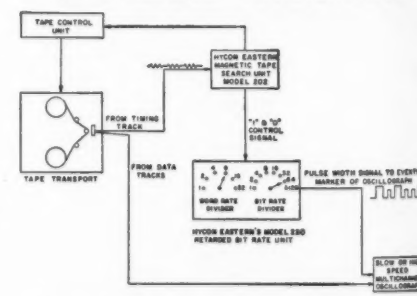
The Retarded Bit Rate Unit, Model 220, when used with the Hycon Eastern Digital Timing Generator, Model 201, or Airborne Digital Timing Generator, Model 206A, provides a universal timing system with format signals suitable for recording on magnetic tape, slow or high speed oscillographs, recording cameras, strip chart recorders, etc. During the periods of data reduction the Model 220 is used with the Hycon Eastern Model 202 Magnetic Tape Search Unit for re-recording the true signal from magnetic tape to oscillographs. The Model 220 is also available packed in a 1/2 ATR Box for airborne applications.

For Data Recording



The Digital Timing Generator, Model 201, supplies a tone burst binary coded decimal signal for recording on one channel of a multichannel tape recorder. The Model 220 receives the "1" and "0" control signals from the Model 201 and converts this to a pulse width and pulse height binary coded decimal signal for recording on oscillographs or other data recording equipment.

For Data Reduction



The Retarded Bit Rate Unit, Model 220, receives the tone burst binary coded decimal signal from the tape through the Magnetic Tape Search Unit, Model 202, and converts this to a pulse width and pulse height timing signal which is re-recorded on the oscillograph. The bit rate and word rate are adjusted to conform with the speed of the oscillograph regardless of the speed of the tape transport.

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MILITARY SYSTEMS DESIGN

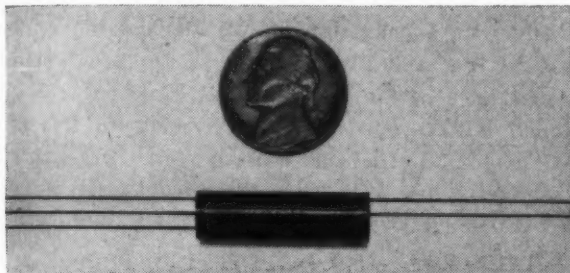
cept for the lens and the metal horns, the dual systems are completely independent and failure of one cannot affect the other. The antenna for either single or double system requires only four square feet of radome area and provides a gain of 29 db.

The system can be fully checked without flight testing. A passive feed horn system measurement of ground speed and drift angle accuracy and simulated high altitude sensitivity can be made while the aircraft is on the ramp. The outputs of the DN-101 are combined with information from a gyro-stabilized magnetic compass and fed to the Collins NC-103 computer to provide direct readout of distances along selected track and across track, and provide inputs to course-deviation and miles-traveled instruments. Computer outputs for a cockpit indicator provide drift angle within 0.5° and ground speed $\pm 0.6\% \pm 1$ knot. The DN-101 System is a development of the Collins Radio Company, Cedar Rapids, Iowa.

For more information circle 79 on inquiry card.

Silicon Transistor Chopper

A new Silicon Chopper designed for low-level voltage measurements, dc amplifier stabilization, high-speed servomechanisms, thermocouple instrumentation and low-level switching is particularly adapted to missile and satellite telemetering applications where power conservation, miniaturization and zero maintenance are necessary. The silicon chopper, operating on familiar solid-state principles has an inherently long life and is not subject to contact bounce, wear, pitting,



or burning. Designated the Model 70, it is the latest in a series of solid-state developments announced by the Solid State Electronics Company of Van Nuys, Calif. (See Figure). The unit may also be used as a demodulator to convert ac to dc.

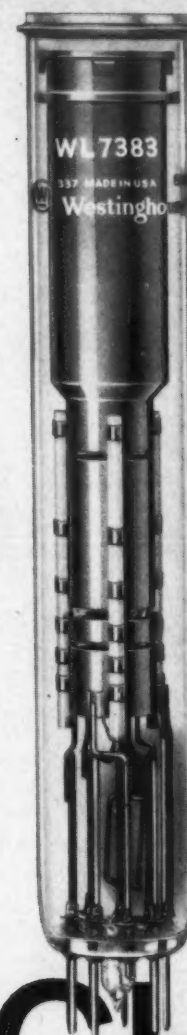
Capable of linearly switching or chopping voltages over a wide dynamic range from less than a millivolt to 10 volts, the switching circuitry used operates the transistors in a manner to provide stability and freedom from drift over a wide temperature range. Only carefully selected silicon transistors are used in the Model 70, which is especially recommended for high temperature applications (from -55° to 130°C).

Unlike mechanical choppers which are limited to a narrow and relatively low frequency range due to mechanical limitations, this transistorized chopper is an inertialess device that can be driven from dc to 100 kc or higher. Epoxy-encapsulated, and with a weight of only 2 grams, it withstands a 500 G shock of 11 msec duration, 30 G vibration from 0 to 200 cps, and acceleration to 700 G. Driving voltage is square-wave, 5-10 volts peak to peak and both input and driving source resistance are 600 ohms.

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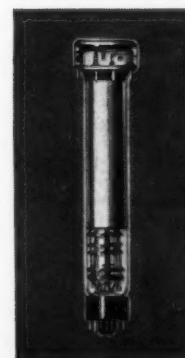
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SAMPLE ORDERS INVITED. WRITE FOR DATA.

The WL-7411 3" Permachon stores an image exceeding the resolution of the image orthicon, and eight shades of gray. It will operate with standard image orthicon components. Storage and read-out are comparable to the WL-7383.



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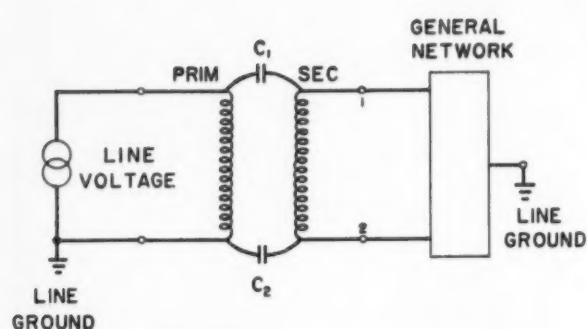


FIG. 1. GENERAL transformer operation.

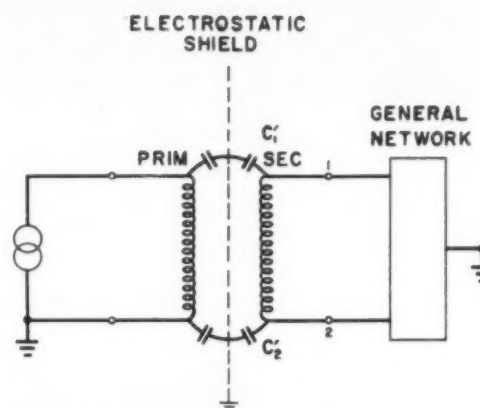


FIG. 2. SHIELDED transformer operation.

generally be ignored in instrumentation work since at these positions all these currents will flow through 1 and 2 as a regular load current. Note also that should the general network be active, or generate ac signals internally, these voltages will cause additional currents and more errors can result.

Conventional Shielding

In the attempt to reduce these general errors, electrostatic shielding is usually utilized. Fig. 2 shows the same circuit as Fig. 1 but with the addition of a single electrostatic shield between windings of the transformer. With an ideal shield, the primary error current will not flow to the secondary or the net-

Isolation of Power Transformers and Power Supplies

J. B. CHATTERTON

and D. G. HOLLISTER, Moeller Instrument Co., Inc.

Chief Engineer-Electronics Div.

Vice Pres.-Engineering

EFFECTIVE CAPACITANCE between the primary and secondary windings of power transformers can cause serious problems in accurate instrumentation work. Conventional methods of electrostatic shielding do not offer a real solution in the general case. However, a special feedback method developed and patented by the Moeller Instrument Co., Inc., of New York City, now enables overall isolation equivalent to that which formerly could only be obtained from battery power. Application of these feedback techniques enable operation of several line-powered devices in the same circuit without common ground connections, even in precise instrumentation.

Capacity Coupling Through Transformers

The basic shielding problem is illustrated by Fig. 1 which shows a line-operated transformer and its effective interwinding capacitance connected to a gen-

eral network, some point of which is tied to line ground. It is this ground—furnished either directly or inadvertently by line-operated equipment such as a VTVM, oscilloscope or amplifier—which causes the problem. It is evident that the line voltage can drive a current through C_1 into the network terminal 1 and through it to ground. If for example, the network is made up of a rectifier, ac filter and resistance bridge, this current will develop an unexpected ac voltage at the bridge output. In addition, the induced voltage in the secondary will cause a current through C_2 to network terminal 1 to ground and another current through C_1 to terminal 2 to ground. These two secondary currents will be in opposite direction and cancellation in the ground line could be achieved only if C_1 and C_2 are equal. Ground current is, of course, the simplest indication of the lack of isolation. Only if the ground is at terminal 1 or 2 can these currents

work since it is effectively shunted to ground by this shield. The secondary currents, however, will flow in the network just as before, but now through C_1' and C_2' . This will be more readily seen by an example.

Consider the ideally shielded transformer of Fig. 2 with a rectifier and filter, forming a d-c power supply, driving a strain gage bridge measured by a grounded VTVM. The equivalent circuit for this is shown in Fig. 3 where E represents the secondary a-c voltage. When E is instantaneously positive as shown, it will drive a current through C_2' , L_1 and R_1 to ground. Assuming C has zero impedance to ac voltages, E will also drive a current through C_2' , L_1 , C and R_2 to ground. These two currents are obviously in phase. Likewise two currents will be driven through R_1 and R_2 and C_1' and L_2 . This pair of currents will be opposite in sign to the first pair. If the rectifier and filter are symmetrical, and if C has zero impedance cancellation will result when C_1' is exactly equal to C_2' .

This cancellation is difficult to accomplish in practice, however, and also difficult to maintain. Without cancellation, these currents will cause a reading on the VTVM for general values of R_1 and R_2 . Note that the ac voltage across C is still zero but not at the VTVM input. This demonstrates the inability of filtering to eliminate these error currents. Assuming infinite back resistance of the diodes, no error currents will flow the following half cycle when E reverses sign. A full wave rectifier will behave similarly but the error currents will flow at all times producing a sine wave of error currents and voltages. In order to determine the approximate error which could arise in practice, if the value of C' is taken at

FIG. 3. SHIELDED power supply—equivalent circuit.

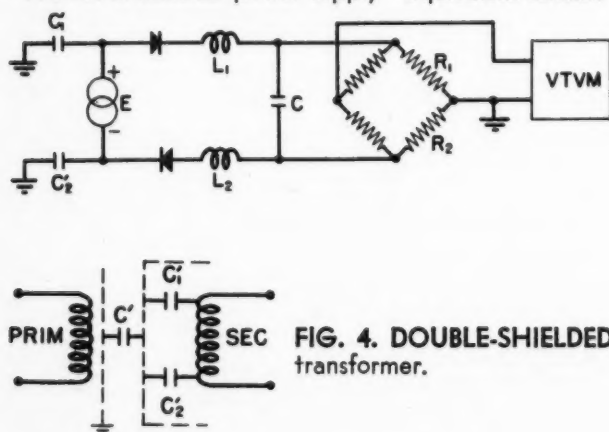
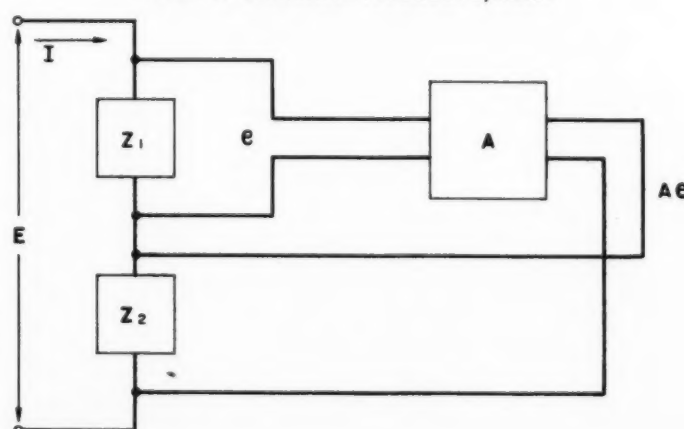


FIG. 4. DOUBLE-SHIELDED transformer.

FIG. 5. GENERAL feedback system.



150 μf and assumed balanced only to one part in five; with a 200 ohm bridge an error of 34 microvolts would result for an E of 30 volts at 60 cycles. Note also that the R_1 and R_2 bridge arms are loaded by reactive elements as is easily seen by imagining an a-c generator in either arm.

To improve matters somewhat the double-shielded transformer with an additional ungrounded shield (Fig. 4) is sometimes used. If Fig. 3 were redrawn for this device, the only difference would be that capacitor C' would be included in the common ground lead. Since the value of C' would be comparable with C_1' and C_2' , an improvement by a factor of about two might be realized because of ground

Power Supplies

current reduction. This configuration can sometimes aid in some degree the long time stability of balance of C_1' and $2'$ but, basically, there is little improvement in overall isolation.

It becomes obvious that fundamental isolation improvement can be obtained only by significant reduction of the transformer capacitances. As long as an iron core is used, physical separation of coils does little because the conduction of the iron electrically joins the coil-core capacitance of each winding. Air or ferrite cores cannot be used at power frequencies, of course, with any practical efficiency. It is, therefore, apparent that a new approach is necessary for extreme isolation.

Feedback Isolation

Now consider the schematic of Fig. 5. The arbitrary impedances Z_1 and Z_2 are in series with a driving voltage E. An ideal or operational amplifier having an amplification factor of A is connected with its input across Z_1 and output across Z_2 . Now the amplifier voltage is seen to be

$$e = IZ_1 \quad (1)$$

and since the output impedance of A is zero or otherwise small compared with Z_2 , the voltage across Z_2 will be constrained to be A e. Summing voltages at the input we have

$$E = IZ_1 + A e \quad (2)$$

or from (1)

$$E = I(Z_1 + A Z_1) \quad (3)$$

The effective input impedance is therefore

$$Z_{in} = \frac{E}{I} = (A + 1)Z_1 \quad (4)$$

Since A can be very large this impedance can be



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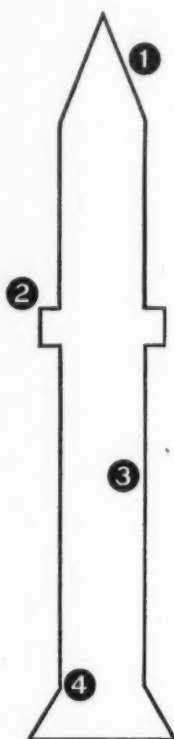
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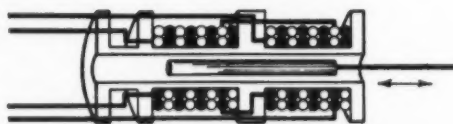


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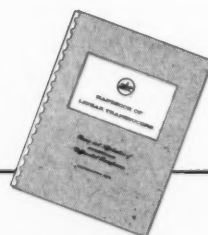
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made very great. Now if Z_1 is a capacitor of capacitance C_s ,

$$Z_{in} = \frac{1}{j\omega \frac{C}{A+1}} \quad (5)$$

which shows that the effective capacitance is reduced by the factor $A+1$.

From the above discussion, the isolation circuit of Fig. 6 is developed. Here each coil is separately shielded and in turn each coil shield is shielded from the other by a center shield which includes the iron core. Any voltage in the primary or secondary circuits which tries to drive a current between the two will now find that C_s has an effective capacitance

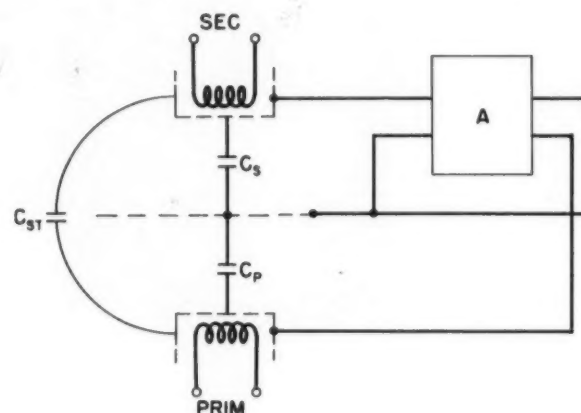
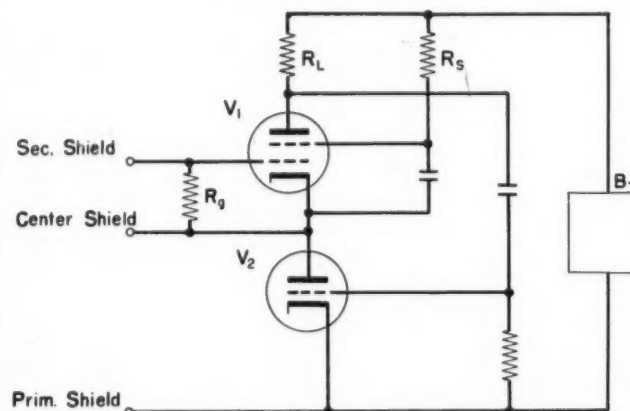


FIG. 6. FEEDBACK isolation system.

FIG. 7. FEEDBACK amplifier schematic.



of $C_s/(A+1)$. There is a stray capacitance C_{st} , however, which is the direct capacitance between windings or their shields which effectively shunts the feedback circuit. It has been found experimentally that such strays can easily be held to about $1\mu\text{f}$ or less. Since C_s is approximately $300\mu\text{f}$ as before, an amplifier gain of 1000 will reduce the total capacitive coupling to about $1.3\mu\text{f}$. Of course, with more elaborate shielding and more gain this could be reduced even more.

One important practical detail in realizing the above isolation scheme is the matter of B supply for the amplifier. Assuming batteries impractical, such a supply will not be isolated from the line so that the



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amplifier must also provide isolation from the secondary and center shields to the B supply. A schematic of a suitable isolation feedback amplifier is shown in Fig. 7. It must be assumed that the B supply is at ac line potential or connected directly to the primary shield as shown. The approximate equivalent circuit for this configuration is shown in Fig. 8, where E is any driving voltage between primary and secondary. It is seen that the only effect of the B supply is to cause a direct shunting from primary to secondary shields by the grid-plate capacitance of pentode V₁. This is very small, of course, and negligible to the stray capacitance C_{st} mentioned above. Coupling due to filament supply is negligible due to the inherent shielding of unipotential cathodes.

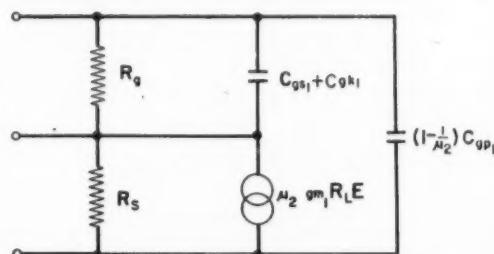
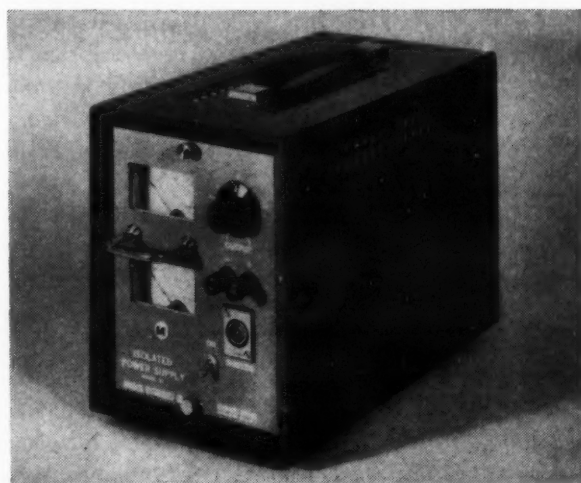


FIG. 8. ISOLATION amplifier—equivalent circuit.

FIG. 9. MOELLER 0-20 volt dc Regulated Power Supply.



These principles have been incorporated into the design of a 0 to 20 volt dc regulated power supply which is shown in Fig. 9. The front panel and outside cover are connected electrically to the primary shield while the output rectifier, filter and transistor regulator are entirely enclosed by the secondary shield. The center shield in turn encloses all of the secondary shield. This arrangement results in a total capacitance of less than 2.5 μf between the output terminals and line ground and less than 0.1 μf to line voltage. Without any special balance of capacitance to ground, a total error current of less than 15 millimicro amps flows so that an error voltage of only 1.3 microvolts appears in a 200 ohm bridge. In order to realize this accuracy, ripple is held to less than 100 microvolts.

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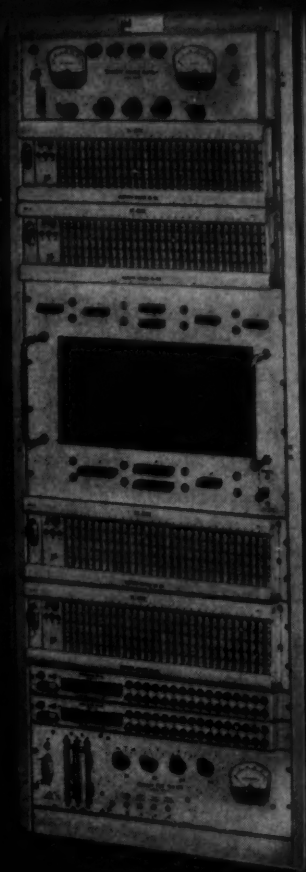
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**Table I. Comparative Characteristics,
Step Motor vs Typical Servo Motor**

ITEM	Size 5		Size 8		Size 11		Size 15	
	Servo Step	Mtr Servo Step	Mtr Servo Step	Mtr Servo Step	Mtr Servo Step	Mtr Servo Step	Mtr Servo Step	Mtr
Stall Torque (oz-in)	0.07	0.4	0.34	1.0	0.63	1.5	1.45	2.0
Input Power (watts)	2.0	5.5	3.0	6.5	3.5	6.5	6.2	6.5
Running Torque (Approx) @600 rpm (oz-in)	0.06	0.08	0.30	0.1	0.55	0.2	1.30	0.25

A NEW type of servo element, the "Step Motor", differs from conventional ac servo motors in that it operates on dc voltages which are switched at any desired stepping rate, whereas normal servos operate on a uniformly rotating field generated by an ac current. The stepping motor can be considered as basically a "variable low-frequency" motor which may be required to operate at frequencies from 0 up to 120 pulses per second.

Basic design parameter differences are compared in Table I. Note that the step motor characteristically operates best at stall torque (zero frequency of ro-

tation), whereas the servo motor can operate at stall torque but is normally designed to operate at a substantial speed. Typical switching rates of 20 to 120 pulses per second for step motors compare with standard servo frequencies of 60 and 400 cps.

Running torques at high RPM is a different matter, however. Here the step motor loses out to conventional servo motors. Also the power consumption is higher on the step motor due to its dc operation. In outward appearance (size and configuration) step servo motors are identical to conventional servo motors (Fig. 1).

STEP SERVO IS NATURAL MATE FOR DIGITAL COMPUTER



FIG. 1. STEP SERVO is identical in appearance with ac servo motor.

Operation

The step motor is designed to convert digital data for analog presentation or operation. That is, supplied with data in digital or pulse form, the step motor with its associated circuitry will provide a means of activation by pulses. These pulses can, in effect, be "counted" by the motor, and by connection into control devices, control a servo valve position, drive a counter, rotate a shaft, or accomplish any other direct activation demanded. The step motor is merely the "muscle." A logic circuit must be utilized to control the operation of the motor. With power transistors, this is no problem.

The sequence of input polarities required from the logic circuitry to drive a step motor through 180° of rotation is shown in Fig. 2. A continuation of the sequence will be seen to achieve 360° rotation in 8 steps. This can be continued indefinitely, also the sequence and rotation can be reversed by any number of means. For example, a multi-pulse switch or commutator could be used to "slave" a remote step-servo by using the principle outlined above.

Users of step servos frequently employ solid-state flip-flop circuits combined with pulse demand circuits to accomplish clockwise and counter-clockwise rotation, over a variety of speeds and loads. Because a number of such circuits are restricted by patents, no attempt will be made here to sketch a typical transistorized control circuit.

Running torque of a typical step motor falls off to about 0.2 oz-in at the 80 pps range, dependent upon load inertia. Investigation into methods for overcoming this characteristic are being made; one method being to combine some of the load characteristics of the ac servo motor in the step servo. At high pulsing rates, the step servo motor appears to operate fairly efficiently as a permanent magnet synchronous de-

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THE SPOT LIGHT is on a new product

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CAMBRIDGE DIVISION, CAMBRIDGE, MARYLAND

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vice. Research into development of this aspect also is being pressed.

The power consumed by the step motor at low pulsing rates is determined entirely by the winding resistance and input voltage. Most applications to date have used the size 11 frame with 28 v dc applied to a winding resistance of 120 to 300 ohms. The magnetic efficiency of a typical motor varies with the resistance of the winding, since more ampere turns can be achieved using a low winding resistance. Experimental models have been manufactured with resistance of only 15 ohms. The input power on 28 volts was then approximately 50 watts per pulse. Natu-

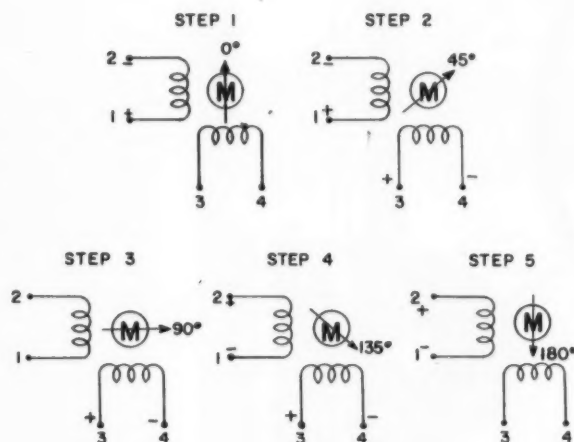


FIG. 2. SEQUENCE of input polarities drives step motor through 180° of clockwise rotation.

rally the temperature rise with such a power level is considerable. A practical value of 120 ohms provided a moderately-powered compromise (6.5 watts/pulse) requiring only moderate heat dissipation.

In many applications the windings are center-tapped. This connection permits reversal of winding polarity by applying power to alternate halves of the winding. This use doubles the power, such that for a 120 ohm winding (60 ohm to center-tap) the motor consumes 13 watts to achieve the same torque. If winding resistance is increased, torque falls rather slowly, being a function of ampere turns. At the 300 winding level, the motor consumes a modest 5.2 watts per pulse, but develops only 1.2 oz-in torque at stall in comparison with 1.6 oz-in at the 120 ohm level.

Induction Motors of California has developed a size 5 step servo motor yielding from 0.3 to 0.5 oz-in torque. Also in development is a size 23 designed to yield 8 to 10 oz-in stall torque.

In conclusion, the step motor is a versatile component which has peculiar talents for teamwork with digital computer and power-transistor circuitry, to provide simple and reliable displays or operational outputs.

For more information circle 82 on inquiry card.

SPECIAL REPORT ON STEP-SERVO MOTORS:



Induction Motors of California Offers Step-Servo Motor Line

A full line of step-servo motors, sizes 5, 8, 11, 15 and 23, designed for digital-to-analog conversion in 45° increments up to 120 pulses per second, are manufactured by Induction Motors of California. The motors are available with impedance of 15 to 300 OHMS and voltage range of 20 to 50 VDC. Motors operate over a range of -55°C to +125°C and meet environmental requirements of MIL-E-5272B and MIL-E-5400. Stainless steel construction is used, and no mechanical detents are employed.

GENERAL SPECIFICATIONS FOR STEP-SERVO MOTORS



I. M. C. P/N	Dim. in Inches				Rotor Inertia GM-CM ²	Min. Hold- ing Torq. Oz.-in.	Max. Watts Per °
	D	L	P	X			
005-801	.500	1.20	.375	1/32	0.50	0.5	8
9708-024	.750	1.09	.500	1/32	0.65	0.8	10
011-859	1.062	1.36	.625	3/64	0.65	1.4	15
9711-007	1.062	1.76	.625	3/64	2.5	1.4	15
9711-050	1.062	1.78	.625	3/64	2.5	1.2	15
9711-053	1.062	1.36	.625	3/64	2.5	1.0	15
9715-001	1.437	1.75	.875	3/64	2.5	1.8	25
023-801	2.250	1.75	2.00	3/64	5.0	3.0	50

Information on cost, delivery, or additional technical information, as well as information on synchro components and solenoids, is available when requested on your company letterhead.



Induction Motors of California

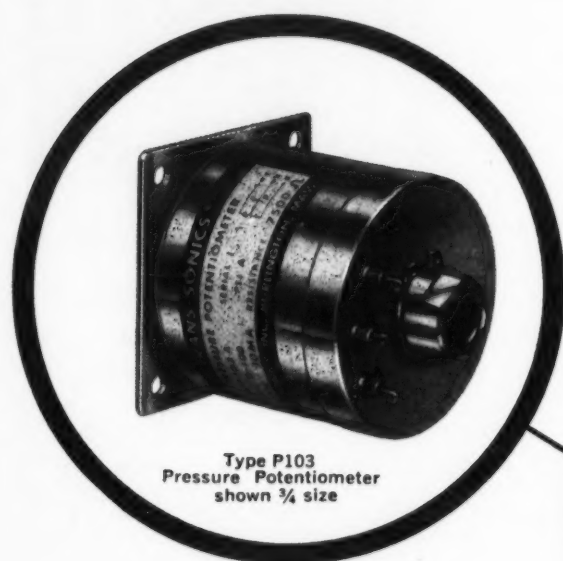
DIVISION OF
INDUCTION MOTORS CORPORATION, N.Y.
6060 Walker Avenue, Maywood, California
LUdlow 3-4785

Representatives in principal cities

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Pressure Potentiometers for...

HIGH TEMPERATURES and CORROSIVE FLUIDS



Type P103
Pressure Potentiometer
shown 3/4 size

New Trans-Sonics* Pressure Potentiometers, Type P103, measure pressures of corrosive fluids such as red fuming nitric acid (RFNA) and unsymmetrical dymethylhydrazine (UDMH) for telemetry and control applications at ambient temperatures up to 600F.

Corrosive fluids are contained by a welded Inconel-X bellows which actuates a dynamically balanced mechanism. This mechanism is hermetically sealed in a stainless steel case for protection against corrosion and other environmental hazards.

Accurate and reliable performance has been proven under the following conditions typical of missile environments: *Random Gaussian Vibration* 0.1g²/cps, 15 to 2,000 cps; *Acceleration* 75g; *Shock* 75g.

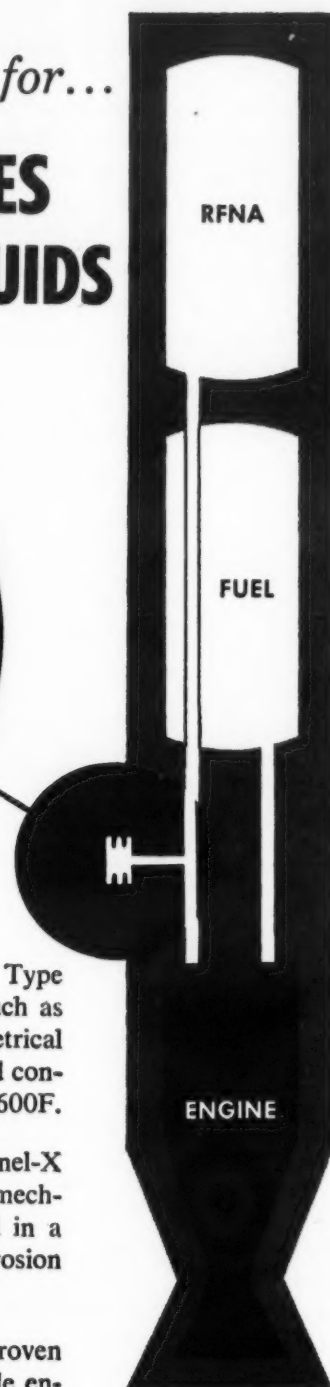
Flexibility of installation is assured by small size and light weight. Dimensions are 1 1/8" diameter by 1 7/8" long. Weight is only 6 ounces. Standard ranges are 0-100 and 0-150 psia . . . other ranges to special order. Write for Technical Bulletin P103 to Trans-Sonics, Inc., Dept. 12, Burlington, Mass.

*TRADEMARK

TRANS-SONICS

Precision Transducers

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LOW-NOISE SAMPLING SWITCH IS JET ACTUATED

SEQUENTIAL SAMPLING of a large number of voltage-generating elements is a standard and widely-used telemetering technique. However, contact "Noise" generated by friction and contacts between switch parts is a source of interference when weak dc signals are being sampled. Mechanical wear, which shortens switch life and produces dust particles, is also a potential source of circuit malfunctions.

A new type of sequential switch (Fig. 1) developed by the Electric Regulator Corporation of Norwalk, Conn., and designated the Roto-Jet eliminates all commutator wear and noise to permit the sampling of signals of 1-to-3 millivolt amplitude without amplification or filtering of any kind.

The principle of the Roto-Jet is shown in Fig. 2. A row of contact modules is arranged around the inner periphery of the shell. An air-jet nozzle on the rotor is successively directed into one module after the next as the rotor turns. Only the air jet enters the module, actuating the movable contact member positively against the rigid fixed contact (Fig. 3). No part of the rotor ever touches the module of the contacts.

The contact pairs are made of palladium, gold, silver, and cooper alloy, selected to minimize contact potential differences. The gentle jet action cannot dislodge particles from metal or insulating surfaces to cause switch malfunction. Also, simultaneous contact of the measuring circuit with two sources at different potentials is eliminated in the Roto-Jet.

The Roto-Jet Model 3745S, comprising 45 pairs of isolated SPST normally-open contacts, is normally operated at 20 rps to accomplish 900 closures per second. Other models are capable of making more than 3600 closures per second. Two-pole switching can be supplied to any phase-angle by adding a second row of contacts and incorporating two synchronized air jets inside the shell. Contact closing time is less than 60 μ sec; opening time is under 80 μ sec.

The new switch can be mounted in any position without affecting its operation. Because its contact design is wiperless, no maintenance is needed. Routine

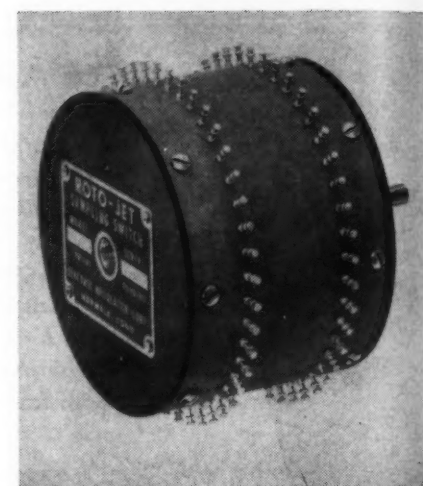


FIG. 1 NOISELESS SEQUENTIAL Sampling Switch, called the "Roto-Jet" uses a rotating jet of air to accomplish up to 3600 noise-free closures per second.

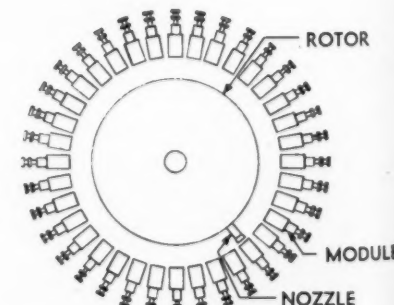


FIG. 2 ROTATING JET actuates switch modules positioned on periphery of switch shell. No part of the rotor ever touches the modules or the contacts.

MILITARY SYSTEMS DESIGN

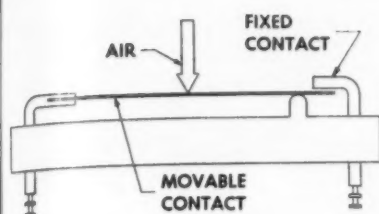


FIG. 3 AIR JET actuates movable contact to make positively with fixed contact. Precious and semi-precious metals are used in contacts.

cleaning of contacts is accomplished while the switch is operating simply by increasing air pressure for several seconds. Operating air required for the switch is $2\frac{1}{2}$ cfm at 35 psi.

The life of the Roto-Jet is indefinitely long. A 2000-hr test made at 20 rps with a load of 50 microamperes at 10 millivolts resulted in negligible contact wear. No noise was visible on a test oscilloscope adjusted for 1 mv/cm amplification. Applications for the Roto-Jet include its use with thermocouples, strain gages, light-sensitive devices, and similar low-level, high-impedance elements employed in computers, telemetering, and complex control systems.

For more information circle 83 on inquiry card.

One-Inch Tape Data System



SPACING:	DIGITAL	ANALOG
INTERTRACK	10 MILS	20 MILS
TRACK WIDTH	20 MILS	50 MILS
CENTER-TO-CENTER	30 MILS	70 MILS
TAPE-EDGE TO TRACK	25 MILS	20 MILS

*THIS ANALOG TRACK RESERVED FOR VOICE OR CLOCK INFORMATION

A new magnetic recording system which puts 108 channels of multiplexed FM/FM data plus the entire output of a 16-bit digitizer on a single 1-inch magnetic has just been announced by the Instrumentation Division of Ampex Corporation, Redwood City, Calif. Designed for instrumentation of advanced power plants for North American Aviation's F-108 and B-70 weapons systems, it will also be used this summer in the J-93 engine test program at Edwards AFB, Calif.

Previous systems need an entire 1" tape for 16 digital tracks, requiring a second recorder when analog data must be simultaneously recorded.

With the new system, 16 digital tracks plus 7 standard analog tracks, (See Figure) or 32 tracks of digital information only may be recorded.

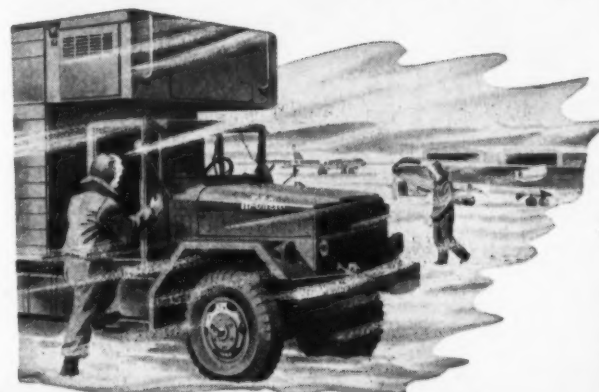
Existing Ampex data recording systems can be converted to the new high-capacity configuration by replacing the heads and adding the record and reproduce amplifiers which are required.

For more information circle 84 on inquiry card.

Note: For 32 tracks digital information the additional 16 tracks are recorded in the space used for analog data in the above illustration.

TAPE UTILIZATION, new head configuration, using 1-inch tape.

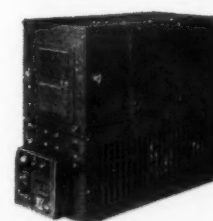
HEAT in military applications



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Hunter Heaters are designed and manufactured in conformity with military specifications for space, equipment and personnel heating in ground support systems for missiles, radar, microwave, monitoring centers, etc. Five basic Hunter models are available currently, some multi-fuel burning, others which burn any type gasoline, each custom-engineered to specific requirements for the area of end use. Model range is from 15,000 to 60,000 BTU/Hour output, all air-circulating, all thermostatically controlled, all designed for cold starts as low as -65°F . One of the current models is...



MODEL UH-68

Produced in conformity with military specification MIL-H 11511B • 60,000 BTU/Hr. output • multi-fuel burning • designated "spec" equipment in

Corps of Engineers' Expansible Body Program, AN/GPQ-T1 Air Force Trainer Radar and many other end item projects in the GCA category • also custom-engineered for the Matador Missile System communications shelters.

MODEL UH-73: 50,000 BTU/Hr. • for guided missile ground control equipment.

MODEL UH-73-2: 50,000 BTU/Hr. • used in U.S. Signal Corps AN/MSG-4.

MODEL UH-58-SC-1A: 60,000 BTU/Hr. • used in S-44, CPN/18A, MPS/7, M-109, etc.

MODEL UH-47-4S: 15,000 BTU/Hr. • for use in small and medium size shelters.

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FIG. 1. NON-CIRCULAR GEARS are more accurate and rugged than cams for generation of empirical functions; can now be economically computed and gear cutter automatically programmed by LGP-30 digital computer.

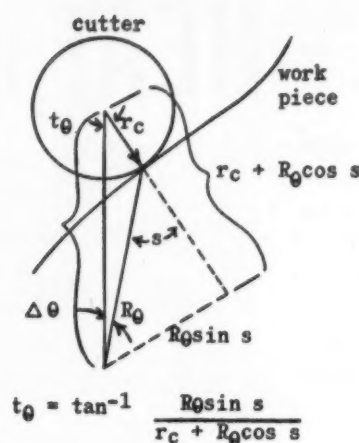


FIG. 2. CALCULATION of D_θ and t_θ

FIG. 3. PUNCHED PAPER TAPE carries instructions to the gear cutter.

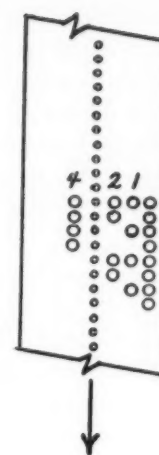


FIG. 4. LGP-30 DIGITAL COMPUTER is supplied with instructions typed on its own keyboard by the gear designer. As a product of its computations it produces punched paper tape to control gear cutter.

Non-Circular Gear Cutting by Computer

A NEED for the mechanical generation of mathematical or empirical functions arises in connection with many problems. Among these are problems connected with the development of fire control and flight control equipment. One important non-classified problem arises in connection with the feed mechanism for motion picture film in cameras, projectors, and film editors.

Classically, generating these functions has been done by smooth cams. However, it can be accomplished by non-circular gears. Such gears are capable of generating any function which does not reverse its slope or have a discontinuity. The ratio of the velocity of the driven gear to that of the driver can vary by more than fifty to one as the driver rotates through one revolution. For many years, machine designers have considered non-circular gears to be mathematical oddities although in function-generating capacities they are superior to cams. They have a high efficiency of power transmission and high accuracy whereas cams have pressure angle problems and lost-motion errors in the follower system (Fig. 1).

One reason why non-circular gears are rarely used in spite of their advantages, lies in the lack of a source of supply. An automatically controlled gear shaper and some facility for automatically computing the control variables is required.

Now a system which can provide the automatic control and automatic computation is available. The automatic control is provided by a Cunningham gear cutter directed by punched paper tape. The Cunningham gear cutter consists of a Fellows Gear Shaper as modified with tape controlled servos by Dr. Frederick W. Cunningham, of Stamford, Connecticut. The automatic computation is provided by the Royal Pre-

cision LGP-30 electronic computer which also produces the punched paper control tape.

It is possible, of course, to accomplish the necessary calculations and punch a control tape by hand. However, several hundred hours of calculation with a desk calculator and manual punching are required if automatic computation is not available. Since the gear cutting system can produce a finished set of gears in less than one hour of operation, it is obvious that a costly and time consuming part of the total effort is in the calculation. With the LGP-30 the entire job of producing the control tape is reduced to a few hours. With the LGP-30 not only are the calculations automatic, but the production of the control tape is also automatic and requires no conversion from cards to tape since the LGP-30 produces punched paper tape output directly. Also, no separate equipment for input data tape preparation is needed since an electric typewriter that produces punched paper tape is part of the LGP-30 computer.

Computation of Control Tape

The problem is to produce gears, to be mounted on shafts, of such a shape as to satisfy the function $\phi = f(\theta)$ where ϕ and θ are the angular displacements of the two shafts, and the input data is in the form of pairs of numbers (ϕ_0, θ_0) , (ϕ_1, θ_1) , etc.

There are three basic parts to the problem solution:

1. Computation of quantities to describe the shape of the gears. These quantities are the radius, arc length, and tangent of angle s for each increment of angular displacement, where s is the angle between the common tangent of the gears and the normal to the line of centers.
2. Computation of the quantities necessary for con-

trol of the gear cutter to produce this shape. These quantities are the center distance between the work piece and the cutter, the angle through which the work piece must be moved, and the angle for the movement of the cutter.

3. Conversion of the control quantities into increments suitable for the gear cutter. The increments are one minute of angle for the work rotation, 0.005 of a tooth or 0.075 degrees on a 24 tooth cutter for the cutter rotation, and 0.0001" for the center distance.

First consider the computation of each radius for each increment of gear rotation. Since the incremental arc length da for each increment of rotation is the same for each gear, expressions for arc length can be equated.

$$da_\phi = dr_\phi + r_\phi d\phi, da_\theta = dr_\theta + r_\theta d\theta \text{ and } da_\phi = da_\theta$$

If the center distance is taken as one

$$r_\theta + r_\phi = 1$$

we obtain

$$r_\theta = 1/(d\theta/d\phi + 1)$$

In this case where the function $\phi = f(\theta)$ is expressed in tabular form, the value of $d\theta/d\phi$ must be obtained from a numerical differentiation formula.

The second part of the problem requires computation of the center distance between the cutter and work piece, D ; the angle of rotation of the work piece, G ; and the angle of rotation of the cutter, H . Since two gears are involved, six quantities must be calculated for each point. The equation for the center distance is:

$$D_\theta = \sqrt{R_\theta^2 + r_c^2 + 2R_\theta r_c \cos s}$$

where R_θ is the actual value of the radius, and r_c is

the radius of the cutter (Fig. 2).

The third part of the solution consists of converting differences in center distance, work rotation, and cutter rotation as calculated in the second part to steps of 0.001", 1 minute of angle, and 0.075° respectively. Then the computer steps are punched on the work control tape. A hole punched in the 1 channel of the tape represents one increment in center distance, in the 2 channel it represents one increment in work piece rotation, and in the 4 channel it represents one increment in cutter rotation (Fig. 3).

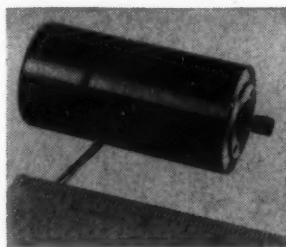
The use of the LGP-30 reduced the calculations necessary to produce a gear cutter control tape from more than 2 man-weeks to a few man-hours, materially reducing the costs and commencing gear production sooner (Fig. 4). The accuracy of computation was more than sufficient to match the requirements of the gear cutter. All these advantages minimize the problems and cost of producing an extremely useful element, the non-circular gear. (From 12-page bulletin No. 701, Data Processing Div., Royal McBee Corp., Westchester Ave., Port Chester, N. Y.)

For this literature circle 85 on inquiry card.

Miniature Motor is Reversible

A 1/50 hp 115v reversible motor, for missile use where single-phase 400 cps power is available, is designed for intermittent duty over an ambient temperature range from -65° to 250°F. When equipped with the 400 cycle brake (Fig. 1) it comes to a stand-

FIG. 1. AYLO MINIATURE MOTOR is equipped with optional magnetic brake.



still within 15 revolutions (unloaded). Reversibility is achieved by the use of a balanced 4-pole winding connected as shown in Fig. 2. Current through the 1.5 mfd condenser leads by 90° that through the directly connected winding to produce an essentially 2-phase magnetic field.

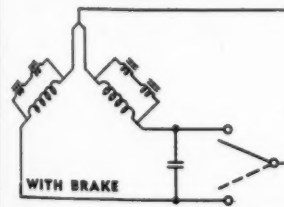


FIG. 2. BALANCED WINDINGS plus capacitor provide reversing circuit for AYLO motor.

The motor is designed for a duty cycle of 3 minutes on, 7 minutes off, with a temperature rise over ambient of 150°F. Motor life is 1000 hours when tested per MIL-M-7969a. Diameter is 1.50"; overall length with brake is 3.5". The magnetic brake has a minimum life of 300,000 operational cycles.—(From data sheet F8580-2, "AYLO 400 cycle AC Motors" Barber-Coleman Company, Rockford, Ill.)

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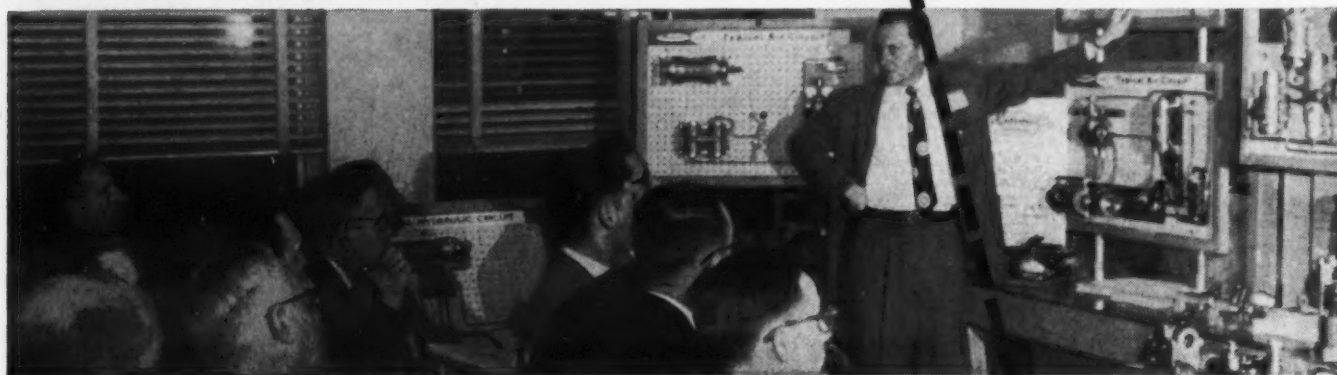
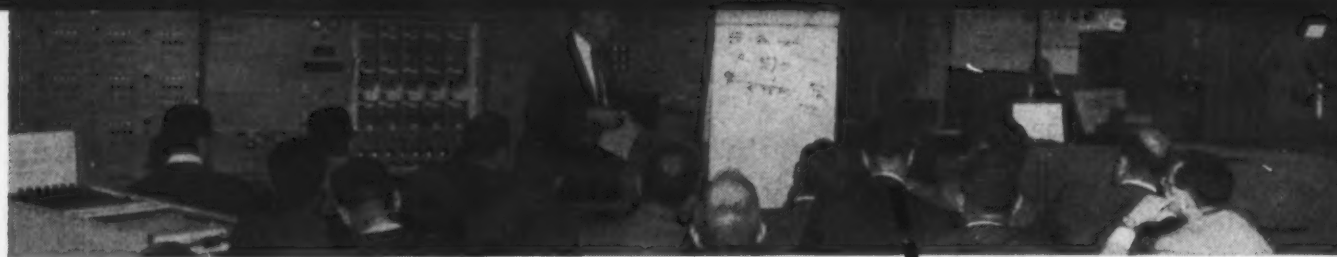
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5- to 200-watt ratings. Complete resistance ranges.	10- to 200-watt ratings. Complete resistance ranges.
Plus/minus 5% tolerance for 50 ohms and over. 10% below 49.9 ohms.	Plus/minus 10%.
Wire leads and lugs in smaller sizes. Lug terminals for larger sizes.	Mounting brackets furnished free with 25-watt and larger sizes.
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N.Y. 17—telephone Murray Hill 8-0980.**

For more information circle 34 on inquiry card.

In the afternoon, a show.



Basic Multiplex Recording System

Data Logger or DL series equipment is used for multiplexing a large number of separate data channels into one or more tracks of magnetic tape storage equipment. The particular forms described herein utilize the popular and well proven pulse duration modulation technique abbreviated PDM (Fig. 1). For high level signals, the basic sampling device used

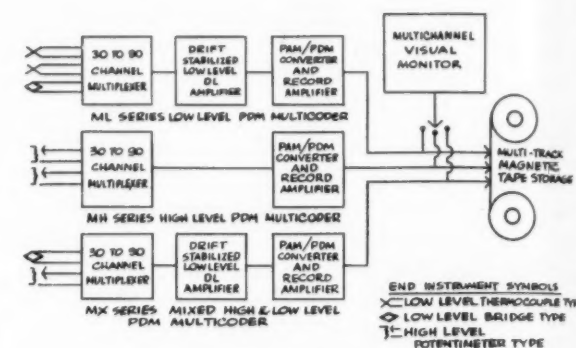


FIG. 1. TYPICAL DATA LOGGER block diagram. (Multichannel Data Acquisition and Storage Equipment)

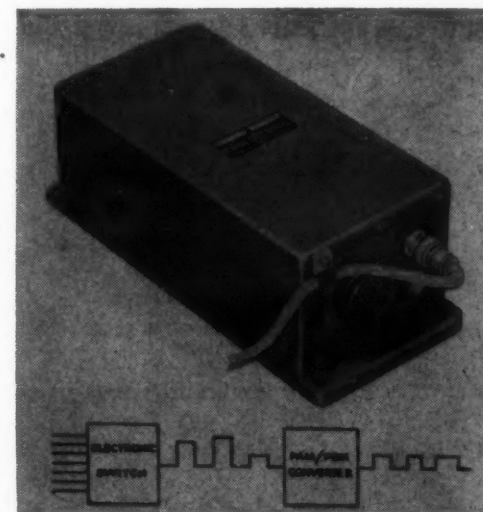


FIG. 2. SOLID STATE PDM Multicoder, Series MH, transforms PAM signals to PDM in RZ mode.

is a unique solid state electronic commutator of advanced design. For low level signals a new compact electromechanical commutator of reliable long life design is used in conjunction with a drift stabilized low level DC amplifier. The commutator output in the form of pulse amplitude modulation (or PAM) is fed into a stable and accurate PAM to PDM converter (often called a keyer). The converter is followed by a record amplifier. Electrically the equipment is solid state in nature wherever possible.



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COMPUTER DEPARTMENT

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Related Equipment

The Data Logger is capable of accepting input signals from all standard and most special end instruments. By use of simple adaptors the equipment can accept almost any form of input encountered. Since the data is stored on tape in standard PDM form, playback is readily accomplished with compatible and standard decommutation and readout equipment. Visual monitor scope equipment for displaying all channels simultaneously, as well as several other useful attachments, can be provided as accessory equipment.

PDM Recording

A PDM modulation system is one in which the amplitude intelligence in a channel sample has been converted to time duration. This is accomplished by amplitude sampling using a simple commutation scheme and converting the resultant constant width PAM signal samples to constant amplitude samples of proportional duration (Fig. 2). The PDM signal thus obtained is applied to the magnetic tape in the form of short unidirectional pulses representing its leading and trailing edges. No current is supplied to the re-

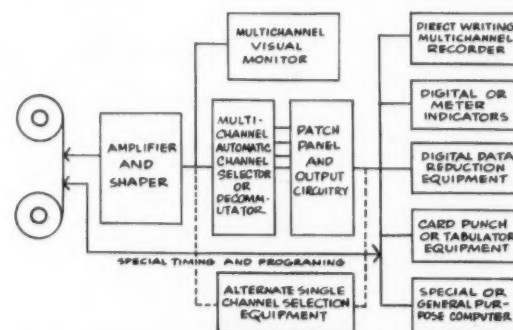


FIG. 3. PLAYBACK AND ANALYSIS equipment, typical block diagram.

cording head except during the pulse period. The resulting signal to noise ratio is very high since background noise is merely the small amount of fluctuation noise created by the motion of the demagnetized tape through the head.

In general, the recording method employed here (commonly called the return-to-zero or RZ method) has the advantage of imposing only moderate demands on the tape. Amplitude linearity of the tape, for example, is not of any importance in this system. It should also be noted that there is a distinct advantage over certain digital methods of recording requiring a non-return-to-zero method in order to achieve a practical pulse packing density on the tape. For Data Logger playback the reproduced pulses are used to recreate the original PDM signal recorded using very simple and reliable regeneration circuitry (Fig. 3).—(From 36-page catalog No. 900, Multichannel Telemetering Equipment, General Devices, Inc., P. O. Box 253, Princeton, N. J.)

For this literature circle 87 on inquiry card.

A Logical Deduction

Because ordinary magnetically-regulated power supplies are too sluggish to handle load and line transients,

Because NJE refused to be satisfied with such performance, and developed, back in 1956, a fundamentally superior circuit,

Because this thoroughly proven circuit uses the speed and power-gain of a transistor amplifier to force rapid response from the magnetic amplifier,

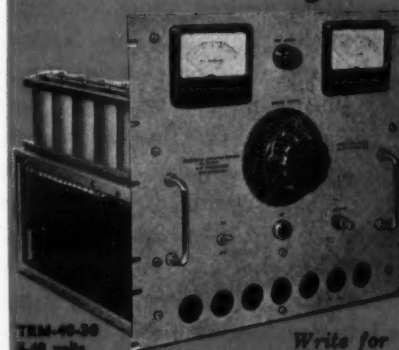
Because the transistors are never in the power path, but handle low-level signals only,

Because this transistor-magnetic—"TRM"—circuit retains the reliability and economy of magnetically-regulated supplies, but greatly improves speed of response (15 millisecon. typical) widens operating range (8:1 typical) and tightens regulation (0.1% typical),

Because TRM supplies can be "zero-lagged" against line and load transients,

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TRM-40-30
5-40 volts
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MODEL NUMBER	OUTPUT RANGE	
	VOLTS	AMPERES
TRM-28-30	24-32	0-30
TRM-28-60	24-32	0-60
TRM-28-120	24-32	0-120
TRM-40-15	5-40	0-15
TRM-40-30	5-40	0-30
TRM-40-60	5-40	0-60
TRM-40-120	5-40	0-120
TRM-80-7.5	10-80	0-7.5
TRM-80-15	10-80	0-15
TRM-80-30	10-80	0-30
TRM-80-60	10-80	0-60
TRM-160-7.5	20-160	0-7.5
TRM-160-15	20-160	0-15
TRM-160-30	20-160	0-30



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FIG. 1. SHOCK TUBE Compression chamber (right) moves on rollers to permit insertion of rupture diaphragm. Camera-recording oscilloscope (left) is set to record gage response; the three schlieren stations for shock-wave velocity measurements are also seen along the expansion section of the tube.

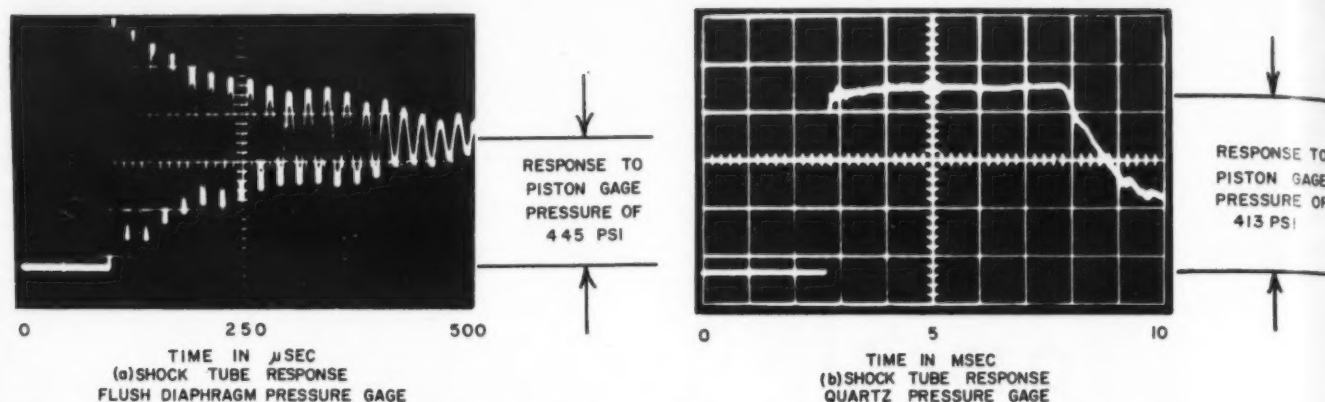


FIG. 2. RESPONSE OSCILLOGRAMS for (a) typical flush diaphragm, and (b) quartz type pressure gages.

NBS TELEMETERING TRANSDUCER PROGRAM

THEMETERING of flight data—an essential part of missile and aircraft testing—is often limited by a lack of information on the performance of transducers. To obtain the necessary data on these important devices, which convert mechanical quantities to electrical signals, the National Bureau of Standards is carrying on a special program of research, development and testing.

As a part of this program, test methods pertinent to the selection, application and improvement of transducers are currently being developed by the NBS for Navy's Bureau of Aeronautics, the Air Force, and the Army Ordnance Corp. Data on the inherent characteristics of the principal types of transducers as well as a better understanding of the requirements for various applications have thus far resulted from the study.

Transducers—electromechanical devices for converting pressure, displacement, acceleration, force, and similar mechanical quantities to electrical signals—are widely applicable, but are in greatest demand for missile and aircraft flight testing. In such use, the electrical output of a transducer is transmitted by a wire line or radio telemetering link to a recording device. However, a serious drawback to the use of telemetering systems is the limiting performance of the transducer itself. A primary reason for the present program is to establish a satisfactory basis for transducer testing and selection and to provide adequate data on transducer performance.

In addition to general performance studies, attention has been focussed on special problems, such as those which appear in pressure and acceleration measurement.

Pressure Gage Calibration

In missile and aircraft flight testing, more measurements are made of pressure than of any other quantity. To obtain more information on the dynamic performance of pressure transducers, a new shock tube designed and built under the supervision of R. O. Smith and P. S. Lederer has been employed (Fig. 1). This apparatus provides a pressure step-function of known value, which can be applied to the transducer pressure gage under study; the response of the gage is then detected by an oscilloscope and photographically recorded for further analysis. So far, it has been necessary to use step input rather than sinusoidal inputs, and the NBS data-processing laboratories are working on the development of analog-computer techniques for deriving frequency-response characteristics directly from step-function response records. A simple system of analysis using a panoramic analyzer from a tape or drum recording of the pressure response is also under development. Response oscillograms are shown in Fig. 2, for (a) typical flush diaphragm and (b) quartz type pressure gages.

The shock tube is constructed of flanged steel sections with a working cross-section 3" square, a compression chamber variable in length from 3.4 to 12 ft, and an expansion chamber 8 ft in length. The interior surfaces of the expansion chamber sections are carefully finished and chrome-plated to minimize "noise" due to shocks reflected from surface discontinuities. The compression chamber sections move on rollers to permit insertion of diaphragms.

The tube is equipped with three pairs of optical

glass windows, each pair provided with a schlieren system and photomultiplier tube arranged to give a pulse at the time of passage of the shock wave. Auxiliary equipment is used to accurately measure the initial expansion—chamber pressure, and to determine the transit time of the shock wave between schlieren stations.

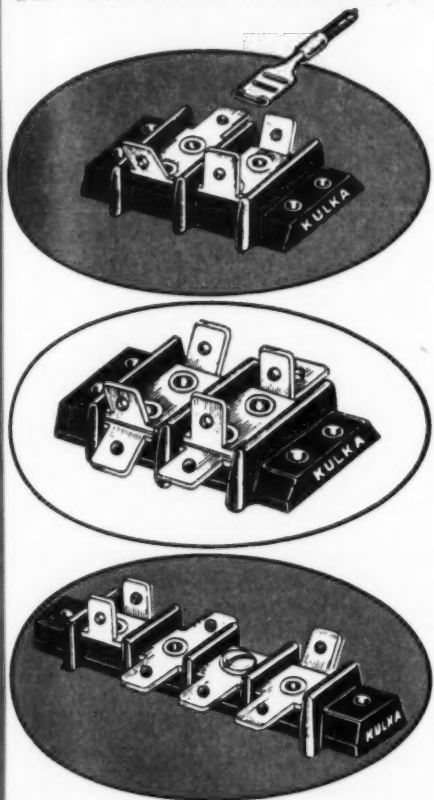
The shock tube provides pressure steps lasting 4 to 5 msec. Compression chamber pressures to 1000 psi and expansion chamber pressures to 350 psi can be selected. If air is used on both sides of the diaphragm, shock steps to 600 psi may be generated. If helium is used in the compression chamber, shock steps to 1000 psi can be produced, the amplitude being determined from the measured value of the initial expansion chamber pressure, temperature and the shock wave velocity. The rise time of the step is less than 10^{-8} sec.

Low-Frequency Accelerometer Calibration

Calibration of accelerometers presents no difficulties at frequencies from 10 to several hundred cps. However, the frequency of interest often lies below 10 cps where satisfactory test equipment has not been available. Two methods have been devised for such low frequency calibrations; one entailing rotation of the accelerometer in the earth's gravitational field, the other making use of a specially designed dual centrifuge (Fig. 3). Either provides a known frequency input to the accelerometer under test; a response curve then represents the dynamic characteristics of the accelerometer.

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For more information circle 36 on inquiry card.

May-June, 1959

The dual centrifuge consists of a rotating table carrying a second smaller rotating table to which the accelerometer is fastened. Both tables rotate in horizontal planes with such a speed that the test accelerometer is carried around a circular path without rotation. This arrangement provides a sinusoidal input for the ac-

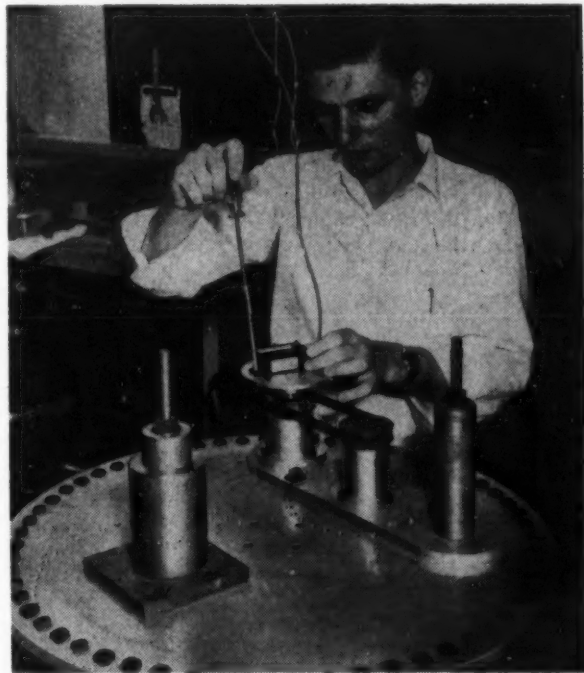
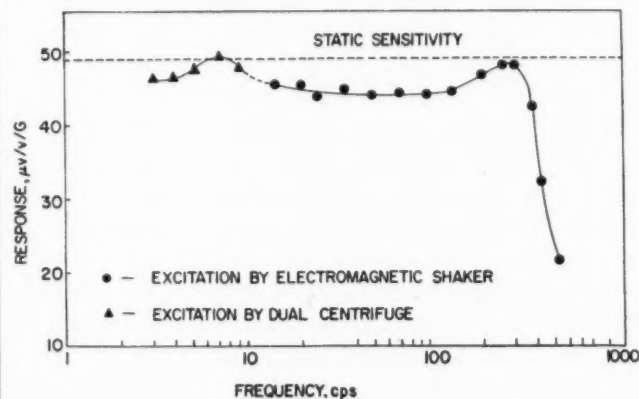


FIG. 3. DUAL CENTRIFUGE provides low-frequency calibration technique for accelerometers.

FIG. 4. RESPONSE CURVE of typical accelerometer is extended into low frequency region by dual-centrifuge method.



celerometer and also allows electrical connections direct to the accelerometer. The dual centrifuge allows calibration from $\frac{1}{2}$ to 10 cps, with an acceleration amplitude of ± 25 G at 5 cps and about ± 1 G at 1 cps. The vertical rotation procedure allows accelerometer calibration from 0 to 30 cps but limits the acceleration range to ± 1 G and requires slip rings to maintain the electrical connections. Fig. 4 shows a typical accelerometer response curve, the lower region of which was obtained by the dual centrifuge method.

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For personal interview with members of our technical staff contact Mr. Colby Ross at the convention hotel Columbia 5-9919.



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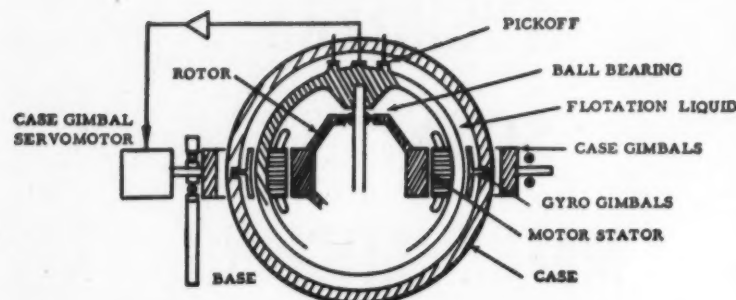


FIG. 1. CONVENTIONAL FLOATED GYRO supports rotor on low-friction ball bearings.

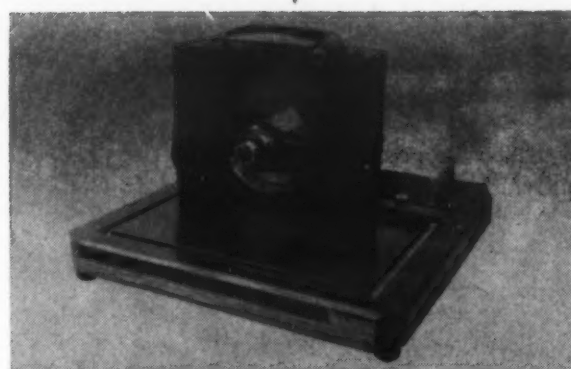


FIG. 2. GAS BEARING in laboratory model has been spinning for more than six years. It is similar to bearings used in inertial navigation systems made for missiles and the Polar-navigating USS Nautilus and Skate by the Autonetics Div., North American Aviation.

Gas Spin Bearings For Gyroscopes

JOHN SLATER

Staff Specialist, Inertial Navigation Engineering Dept., Autonetics, a division of North American Aviation, Inc.

GYROSCOPES for inertial navigation on the earth, and for ballistic missile guidance systems, have extraordinary requirements as regards accuracy—requirements often hundreds or thousands of times as strict as for ordinary flight instrument and flight control gyroscopes. This is because in guidance systems the set of gyroscopes is employed as the primary space reference—as a sort of substitute for the “fixed space” as defined by the stars in celestial navigation. Gyroscope drift is as if one were steering by a drifting star; large errors can accumulate from small drift rates.

For extra-terrestrial application, accuracy requirements are in general somewhat relieved, but a new and onerous requirement is imposed: well-nigh absolute reliability and constancy of characteristics, over periods of months and years.

The essential element of any gyroscope is a spinning rotor. It is mounted in gimbals or the equivalent in a manner such as to uncouple the rotor, so far as possible, from the base so that the rotor will not be dragged by or otherwise coerced relative to the base and can serve to maintain an accurate space reference.

Fig. 1 shows the elements of a representative gyroscope of a conventional two-degree-of-freedom type. The rotor is supported in ball bearings in a spherical

float of great rigidity, which in turn is supported by low-friction bearings in a gimbal. The case is filled with floatation liquid to take the load off the low-friction bearings. An electrical pickoff (position transducer) detects angular departure of the case relative to the spin axis, and operates servo systems at a set of case-supported gimbals to maintain alinement. Thus the case is in effect “slaved” to the rotor as if it were a telescope aimed at some fixed star.

Ball bearings for the rotor, as conventionally used, can fill requirements of rigidity, accuracy, reliability and longevity, to a fairly high degree—provided extreme care is used all along the line, in fabrication, assembly and use. Even so, they leave something to be desired. Any machine that involves rolling metal-to-metal contact is inevitably subject to vibration, shifting of parts, and wear. To be sure, actual failure may not come into question—a good ball-bearing assembly may run for thousands of hours without breakdown—but gradual change of characteristics, and consequent development of a drift rate, is apt to occur.

Gas Bearings Contrasted with Ball Bearings

Gas-lubricated spin bearings have been developed to carry gyroscope performance to a new level, beyond that attainable with traditional mechanical bearings. Metal-to-metal contact is avoided by supporting the rotor on a thin film of gas (typically hydrogen, helium or neon). While the bearing is running, wear is completely absent. Properties of the gas-lubricated bearing are not subject to change, whether from day to day

or from year to year. Also the vibration level is practically zero (Fig. 2).

A person unfamiliar with gas-lubricated bearings may tend to think of them as something weak and flabby. Actually they are typically more rigid—less deflection per pound of load—than the steel ball-bearings which they replace. They can readily be designed to withstand the terrific accelerations associated with ballistic missile launchings—10G, 20G and higher.

The reason for the remarkable stiffness is as follows. The opposing members of the bearing (i.e. the rotor and stator) typically have areas of several square inches, whereas the gap is only a few ten-thousandths of an inch. The setup resembles a piston-and-cylinder combination with a very thin gap between the piston and the cylinder head. Attempt to close the gap is associated with a very large fractional reduction of the gap, hence buildup of opposing pressure.

In ball bearings, on the other hand, while the balls and races are of hard steel, the total actual contact area is extremely minute compared to the support area of the gas bearing. The net effect of area turns out to be at least as significant as that of “hardness” of the supporting medium, so that the stiffness of the two different kinds of bearings are comparable.

Figure 3 illustrates graphically the different degree of smoothness and rigidity of ball bearings and gas spin bearings. The drawing is taken from oscillograph photographs showing the trace of the instantaneous axis of a spinning rotor, on a plane at right angles to the axis. (The rotor assembly was mounted in electro-

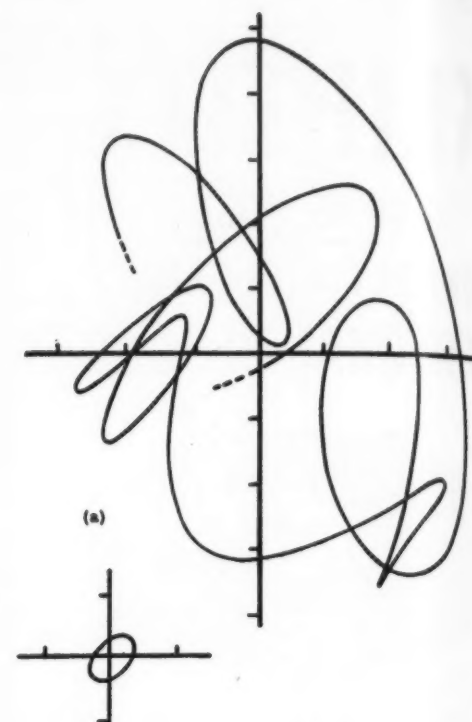


FIG. 3. OSCILLOGRAPH TRACES of instantaneous axis position of spinning rotor, (a) mounted in ball-bearings; (b) mounted in gas-spin-bearing. Small amount of harmonic dynamic unbalance shown by gas spin bearing could also be corrected.

* Gas bearing work on which this article is based is attributable to the following Autonetics engineers: J. J. Ausman, J. C. Boltinghouse, S. W. Cogan, W. A. Ebert, and Manfred Wildmann.

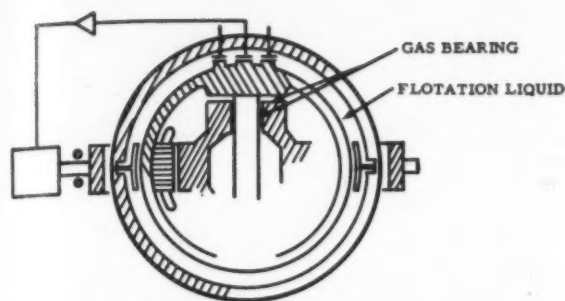


FIG. 4. CONVENTIONAL TYPE OF GYRO with gas-lubricated bearing replacing ball type spin bearings.

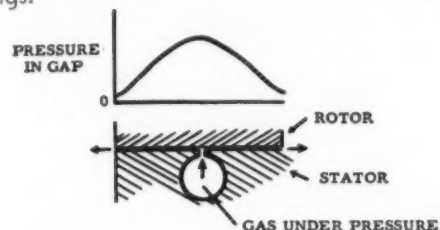


FIG. 6. HYDROSTATIC TYPE BEARING requires gas compressor external to bearing.

magnetic pickups, similar to those in a dynamic-balancing machine, and the amplified pickup outputs applied to the oscillograph.)

Trace (a) is for a ball-bearing-mounted rotor of highest possible precision, operating at 200 rps. The exposure time was such as to include a few revolutions. The trace is of large amplitude, and moreover the pattern never repeats—we have a condition of high noise level.

Trace (b) is for a gas-spin-bearing mounted rotor, under otherwise identical conditions. The trace is of small amplitude, and is a simple ellipse (due to residual dynamic unbalance, which can be corrected). The noise level is practically nil.

One can tell whether a ball-bearing gyro is running or not simply by listening to it, or feeling it. This is not the case with a gas spin bearing gyro—instruments must be used to tell whether it is running or not.

The gas-lubricated bearing finds application to two different kinds of gyroscopes.

One kind is essentially similar to the conventional type except for substitution of a gas-lubricated bearing for ball bearings (Fig. 4).

Free Rotor Gyroscope

The other is of markedly different type, which has no counterpart in ball-bearing equipped apparatus. This is the so-called free-rotor gyroscope.

In the free-rotor gyroscope the rotor may take the form of a sphere, mounted in a spherical gas-lubricated bearing and driven by a motor on the case (Fig. 4). A pickoff senses misalignment of the case and controls case-gimbals to restore alignment.

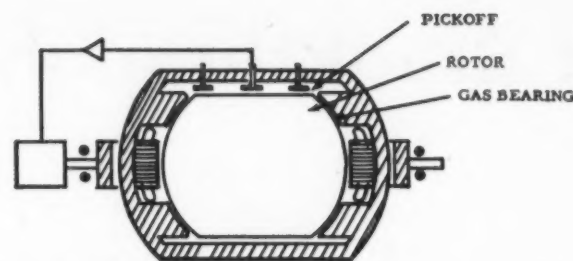


FIG. 5. FREE ROTOR GYRO with rotor support in gas-lubricated "ball-and-socket" joint dispenses with many annoying elements of conventional gyro.



FIG. 7. HYDRODYNAMIC TYPE BEARING acts as its own compressor. Rotor is supported by gas squeezed into constricted area by viscous drag.

It will be observed that the rotor proper is not supported in gimbals—the gas-lubricated "ball-and-socket joint" provides all necessary degrees of freedom, all at one spot. The gyroscopic element is thus reduced to its simplest—hence ultimately the most accurate and reliable—form. Lead-in wires, flotation liquids, complex float structures and a host of other annoying elements of the conventional gyroscope, are completely done away with.

It will also be observed that the essential gyroscopic element, i.e. the rotor, occupies a much larger volume of the total instrument volume than in the other forms of gyroscope. The practical significance of this is that the free-rotor type of instrument can be made substantially smaller, for a given effective gyroscope size, than the conventional type.

Gas Bearing Types

Gas-lubricated rotor spin bearings can be made in both the hydrostatic (compressor-supplied) type and the hydrodynamic (autolubricated) type.

In the hydrostatic type, gas is forced by a compressor into the bearing gap via orifices or slits, in a manner quite analogous to that in pressure-fed oil bearings. The supporting action, analogous to a piston-cylinder action as in a hydraulic press, is indicated in Fig. 6.

The hydrodynamic type requires no compressor. The bearing is designed so that, under load, a wedge-shaped gap exists between rotor and stator (Fig. 7). Gas at relatively low pressure in the wider parts of the gap is squeezed by viscous drag into the narrow part, thereby generating pressure or lift.

Note: Additional preliminary reading on Gas Bearing Design is article by Ausman and Wildmann, page 103, *Product Engineering*, Nov. 25, 1957.



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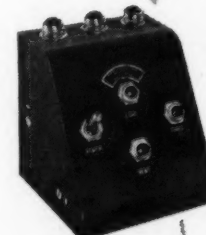
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Computer Readout Breakthrough

COMMUNICATIONS from new high-speed computers, such as the Naval Ordnance Research Calculator (NORC) to the military research scientists awaiting the product of its lightning labors have been a major obstacle in the utilization of this calculator, said to be the world's most powerful tool for rapidly solving complex mathematical formulae. The output of the NORC has previously been in the form of tabular data or its digital equivalent, which must, in many cases, be plotted and suitably displayed before the information could be intelligently utilized by the scientists. Early applications of the NORC and similar scientific computers demonstrated that their calculating speed had far outstripped the ability of available readout devices. This delay in data readout became particularly serious when real-time computation was required to calculate missile and satellite trajectories and solve problems in spatial navigation.

The S-C 4010 High Speed Microfilm Printer, a product of Stromberg-Carlson—San Diego, a division facility of the General Dynamics Corporation, is said to be the first automatic printer to have the speed and accuracy necessary to provide the link between the scientific research computer and its human mas-

ters. This truly high-speed system, capable of recording up to 15,000 characters or plotting points per second has been accomplished by combining the CHARACTRON shaped beam tube (7-inch high-resolution screen) with a 35-mm Traid Automax Camera for high quality permanent recording and a Kelvin-Hughes automatic processing camera for direct viewing of data displayed on the shaped beam tube face. The latter camera can project any display on a viewing screen incorporated in the cabinet in less than ten seconds after film exposure. This process may be used during the 35mm film recording operation, and acts as a visual monitoring device.

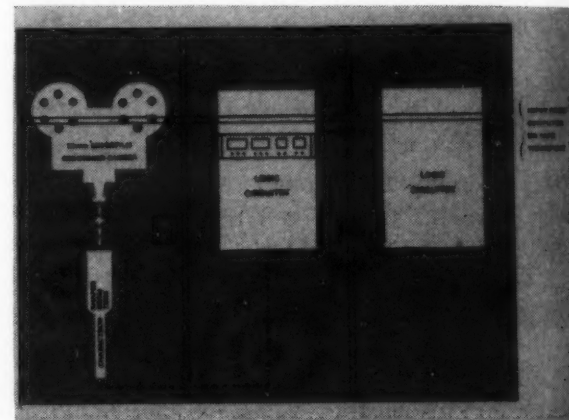
Besides its use as a direct-viewing monitor, the S-C 4010 Microfilm Printer device provides a permanent record of all data, graphs, dimensioned drawings and plain language explanations which combine to make a complete report, on microfilm.

Many features of the NORC Microfilm Recorder have been incorporated by Stromberg-Carlson in the Model S-C 4020 Microfilm Printer which is now available for a wide range of scientific and business applications (Fig. 2).



FIG. 1. RAPID READOUT for the NORC (Naval Ordnance Research Computer) is provided by a new High Speed Microfilm Printer which uses the shaped beam Charactron Tube. (Photo Courtesy of Stromberg-Carlson Co.)

FIG. 2. SIMPLIFIED SCHEMATIC of S-C Model 4020 Microfilm Printer which is available for general scientific and business computer readout applications.



The 4000 Series Microfilm Recorders all make use of the CHARACTRON 7-inch shaped beam tube which uses a 64-character matrix to form individual alpha-numeric characters which in turn are selected and positioned on the face of the tube in a size readable with the naked eye. This selection and positioning is accomplished by digital logic driving circuits generated within the 4000 Series cabinet. Six bits of information are required to select any one of the 64 characters in the matrix, while twenty additional bits are needed to position the character accurately in any one of 1024 horizontal and 1024 vertical positions on the tube raster. Repeatable accuracy of character positioning is within 0.04%. Further technical details and applications data are given in a new 20-page brochure on the S-C 4000 Series which is available from the manufacturer on request.

The 4000 Series Microfilm Recorders can be used either on-line directly from the master computer or can be fed off-line from a magnetic tape produced by the master computer.

Stromberg-Carlson also manufactures the S-C 5000

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For more information circle 40 on inquiry card.

ELECTRONIC HARDWARE



- Terminal Lugs • Insulated Terminals • Electronic Hardware
- Handles • Captive Screws
- Brackets • Dial Locks • Spacers
- Shaft Locks • Binding Posts

Completely assembled terminal boards to meet all government specifications.

Immediate delivery from stock or to order on all items.

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GENERAL COMPONENTS, INC.
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Telephone: MQ 5-0740

For more information circle 41 on inquiry card.

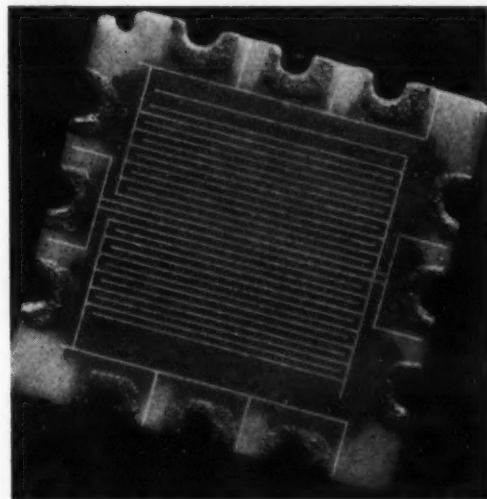
High Speed Hard Copy Printer. This printer combines the CHARACTRON shaped beam tube with a xerographic process to print up to 100,000 words per minute on dry untreated paper, including printing on pre-printed forms.

For more information circle 88 on inquiry card.

Micro-Modular Resistors

New molecular-structured resistors made by inscribing ceramic wafers having a resistive surface layer with a series of isolation lines have been announced by the Daystrom-Weston Instrument Division.

Basically, the micro-miniature resistors are a solid state material in the form of a ceramic wafer approximately 0.010" thick and 0.35" square. (See Figure).



ENLARGEMENT OF 0.35 inch-square microelement resistor shows how resistance characteristics are inscribed in the substrates. (Tiny isolation lines have been retouched in photograph).

The isolation lines shown form a two-maze pattern on each side of the wafer, producing two separate resistors with values ranging from 10 to one-million ohms. Multilayer structures of the micro-element forms can extend this range. Each wafer element, weighing 50 mg, contains four resistors, which averages 40,000 resistors per pound. The stability and ruggedness of the basic substrate enable reliabilities of 100,000 hours to meantime failure, it is claimed.

Automatic production of the micro-element resistors and of their assembly into modular circuit elements is planned. The basic wafers will be stacked or interconnected, as desired, with a space of 0.01" between elements to provide electrical de-coupling and to allow for joints and tolerances.

After assembly of the elements and completion of all internal connections, the circuit element is sealed by molding or encapsulation to form a module. This module can function as a filter, amplifier, oscillator or other type of electronic sub-assembly which is combined with similar modules to form the complete electronic package. Such modules are said to be light and rugged, capable of withstanding extreme shock and vibration.

For more information circle 89 on inquiry card.



MAKE NO MISTAKE...

...this New Universal Bridge is DIRECT READING on all 21 ranges. Results are obtained without calculation, the balance is sharp but easily found, the design is functional. Mistakes are almost impossible with Model 868A—a bridge you will enjoy using.

21 Ranges:
1 μ H to 100H, 1 μ F to 100 μ F, 0.1 Ω to 10M Ω .
Dual Frequency, 1kc & 10kc, 400 cps to order.
Built-in Oscillator and tuned VTVM Detector.
Variable Bridge Voltage, meter-monitored.



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For more information circle 42 on inquiry card.



PRESTO-SPLICE
DIGITAL
TAPE

IN 2
SECONDS

No Adhesives — No Drying Time Required
Perfect Tape Alignment Assured Every Time

- Collect short-ends of information on large reel for single run.
- Insert corrections without re-editing — add or subtract from tape as needed.
- Fused splice works with both mechanical and photo-electric readers.

Now splice all 5 to 8 channel paper tapes IN TWO SECONDS with the miracle Presto-Splicer. A few minutes work can correlate an entire day's programming.

Permanent butt-weld or overlap splice lasts under all use conditions because the splice is actually electrically fused! After splicing, tape maintains original condition — data is neither destroyed nor distorted... with the new information accurately inserted... at a tremendous cost saving in tape. Presto-Splacers are made to meet any size or custom requirement for magnetic tape, digital paper, 35MM film, etc. Find out how — find out why! Send for our brochure.



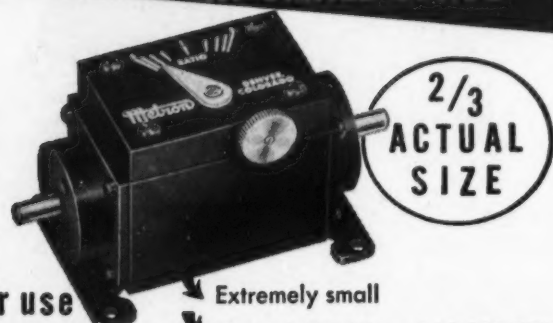
PRESTO-SPLICER

Prestoseal Manufacturing Corp.

37-27 33rd Street, Long Island City 1, New York
Export Dept: Reeves Equipment Corp., 10 E. 52nd St.,
New York City, N. Y. — Cable: Reevesquip, New York

For more information circle 43 on inquiry card.

NEW Metron MINIATURE COMPONENTS FOR ADJUSTABLE SPEED... IN SMALL SPACE



For use

in countless precision devices where continuously adjustable speed is required... If small space and adjustable speed is your problem, investigate Metron Miniature Adjustable Rate Speed Drives TODAY!

- Extremely small
- Up to 0.025 HP and 10,000 RPM
- Choice of 5 speed controls
- All aluminum housing
- Complete, ready-to-go
- Compact, adaptable
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For more information circle 44 on inquiry card.

NETIC CO-NETIC

TAPE DATA PRESERVERS

Keep Data Clear, Distinct, Without Distortion

Permanently maintain original fidelity of recorded data on automation programming tapes, telemetering, broadcast, video and hi-fi tapes by diverting all damaging magnetic fields. Magnetic shielding qualities not affected if sturdy Netic Co-Netic containers are dropped or vibrated. Containers do not retain residual magnetism nor require periodic annealing.



Successfully provide simultaneous high and low intensity shielding plus high and low frequency shielding from all damaging extraneous fields produced by generators, power supplies, transformers, magnetic tables on surface grinders, magnetic chucks, de-gaussers, soldering irons, motors, power lines, welding machines, solenoids, etc. around factories, laboratories, military installations, and radio and TV stations. Available in many convenient round or rectangular shapes. Write for sizes and prices today.

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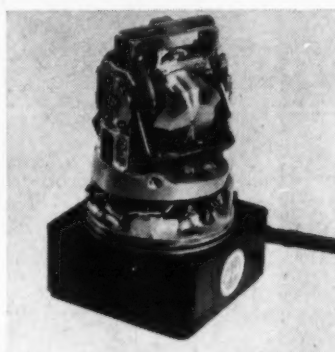
For more information circle 45 on inquiry card.



For Inertial Navigation

FREE GYRO

New FG01-1300 series Free Gyro now being used in a torpedo guidance application employs high strength stainless steel in the spindle and gimbal assembly for maximum strength and rigidity. Available with 28v dc,

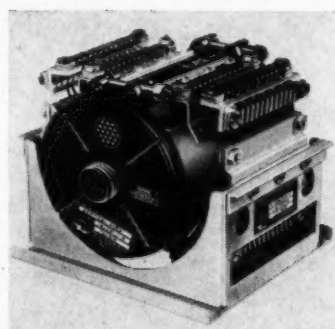


115v 400 cps, or special 800 cps 48,000 rpm motor. For the 800 cps motor a transistorized power supply of 2-gyro capacity is available. The Free Gyro may be supplied with electrical caging and uncaging or manual caging and electrical uncaging.—Humphrey, Inc., 2805 Canon St., San Diego 6, Calif.

For more information circle 90 on inquiry card.

VERTICAL GYRO TRANSMITTER

New Type 1428-1-A miniature vertical gyro transmitter features hermetically sealed hysteresis synchronous motor with speed of 24,000 rpm and moment of inertia of 1200 gm-cm². Operating temperature range is from -55° to 71°C; Autosyn synchro



data transmitter provides a maximum output voltage of 11.8v, with 30 mv max at null, maximum error of 7 minutes and sensitivity of 200 mv degree. Has 360° of freedom in bank with controlled tumbling at 85° in pitch.—Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.

For more information circle 91 on inquiry card.

FLOATED RATE GYRO

New M2500 series miniature high-accuracy floated rate gyro for missiles are only 2" in diameter yet show

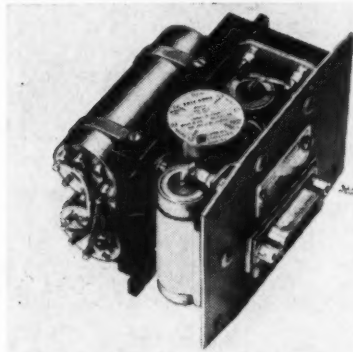


superior performance characteristics: Mass unbalance, 1°/hr max untrimmed; restraint, 0.5°/hr max untrimmed; max drift rate, 0.015°/hr/G² steady acceleration.—Kearfott Co., Inc., 1500 Main Ave., Clifton, N. J.

For more information circle 92 on inquiry card.

RATE GYRO PACKAGE

New subminiature rate gyro package for missile and aircraft flight stabilization provides 3-axis angular velocity sensor in 3" cube weighing

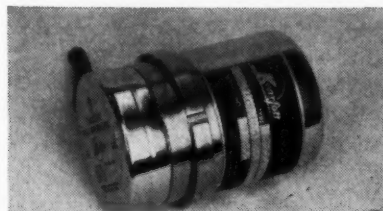


less than 1 lb. Includes three Sanders type RGB temperature-compensated subminiature rate gyroscopes, a phase-splitting capacitor and choke to give constant pick-off excitation despite frequency or temperature variations.—Sanders Associates, Inc., Nashua, N. H.

For more information circle 93 on inquiry card.

MINIATURE RATE GYROS

Miniature fluid-filled rate gyros for precise angular rate measurements despite extreme shock and vibration of missile environments

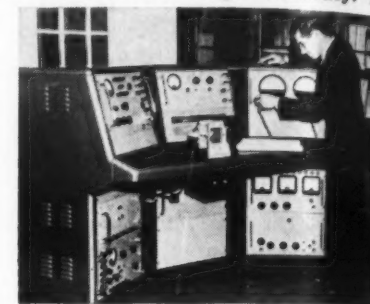


achieve 30-second warm-up time due to heaterless compensation methods for fluid viscosity variation due to temperature changes. Fluid filling reduces bearing and potentiometer wiper friction, provides high immunity to shock and vibration effects.—Kearfott Company, Inc., 1500 Main Ave., Clifton, N. J.

For more information circle 94 on inquiry card.

GYRO TEST CONSOLE

New console designed to measure the transfer function and damping characteristics of rate gyros is engineered for operator's convenience as well as for high accuracy. In-

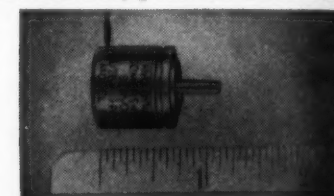


cludes low frequency decade oscillator, low frequency resolved component indicator, carrier converter, power supply, velocity pickup head amplifier, rate vibration table control unit and rate vibration table. Space for gyro spinner motor and pick-off power supply is also provided.—Western Div., Solartron, Inc., 10761 Burbank Blvd., North Hollywood, Calif.

For more information circle 95 on inquiry card.

SIZE 8 SERVO MOTOR

New Model SDC 3/4" Servo Motor, said to be lightest and one of shortest servo motors, produces 1 oz-in torque

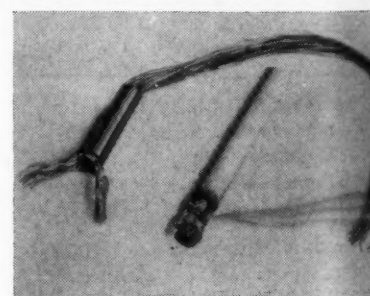


at stall. Input power range is 6 to 115v ac.—Servo Dynamics Corp., Somersworth, N. H.

For more information circle 96 on inquiry card.

STABLE PLATFORM SLIP RING ASSEMBLY

Fifty slip rings, 100 brushes are ballbearing mounted and packaged in a dust-sealed housing only one-half size of a cigarette. Noise levels below 50 μv, with breakaway friction under



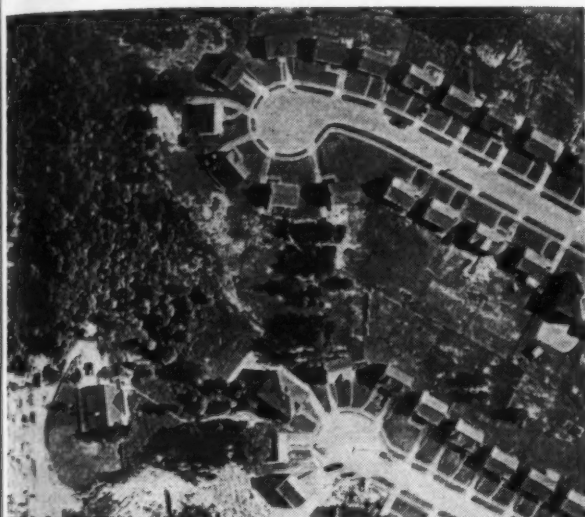
50 gm-cm and brushes tuned to different resonant frequencies are features of assembly which meets Mil-Spec 5400A. Specifications on request.—Slip Ring Company of America, 5456 West Washington Blvd., Los Angeles 16, Calif.

For more information circle 97 on inquiry card.

MILITARY SYSTEMS DESIGN

Rapid Automatic Picture Printer

The view shown is an unenlarged portion of a 9" x 9" xerographic aerial print produced in 22 seconds from an aerial negative by the new Xerox Automatic Picture Printer. This machine, operating on the dry electrostatic principles of xerography, requires no liquids, chemicals, sensitized paper, or darkroom, but produces finished permanent pictures up to 9 inches wide of any length on inexpensive unsensitized paper at the rate of 20 feet per minute. At this rate, a different 9 x 9-inch picture emerges from the printer every 2 1/4 seconds.



SECTION OF AERIAL PHOTOGRAPH printed by new Xerox Automatic Picture Printer.

The machine, developed under the combined sponsorship of the Signal Corps and the Air Force, produces dry prints of unusually high resolution which can be immediately viewed seconds after picture printing begins, which permits photographic "contrast" to be immediately modified as desired by electrical controls on the printer.

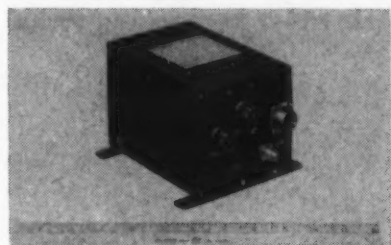
The xerographic process is not effected by gamma and neutron radiation, except during the moment before exposure. In this fraction of a second the electrostatic charge sensitizes the selenium drum, which in turn processes image so quickly that the prints are unaffected. This contrasts with the great danger to stocks of sensitized paper from prompt and residual radiation incident to an atomic explosion. The high speed with which prints may be made available for intelligence study within minutes after the return of a photographic mission is another military advantage of importance.

The Xerox Automatic Picture Printer is now in the prototype development stage and represents a scientific achievement rather than a commercial development, according to Dr. John Dessauer, Haloid Xerox vice president for Research and Development. Haloid Xerox also has developed and presently manufactures the Xerox Copyflo Continuous printing copying machine for copying engineering drawings from microfilm, and the copying machines for rapid reproduction of drawn or printed materials.

For more information circle 98 on inquiry card.

ALTITUDE CONTROLLER

Missile and aircraft barometric controller with infinite resolution acts



as altimeter or provides output for flight control. Standard altitude range is 0 to 100,000 ft with temperature errors within ± 3 ft. from -55° to 71°C .—Electronic Controls Div., General Controls Co., 801 Allen Ave., Glendale 1, Calif.

For more information circle 99 on inquiry card.

MINIATURE ACCELEROMETER

Three-ounce Model GMA accelerometer for missile flight control,

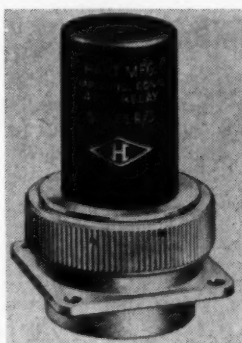


telemetry and aircraft applications covers range from $\pm 0.5\text{G}$ to $\pm 100\text{G}$ with natural frequencies from 12 cps to 75 cps. Temperature compensated to operate to specifications between -20° to 250°F .—Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.

For more information circle 100 on inquiry card.

AIRCRAFT RELAYS

New "Diamond H" Series R/S miniature, hermetically sealed aircraft type 4PDT relays are now available with AN type connector. Feature high sensitivity, excellent resistance to temperature (200°C or



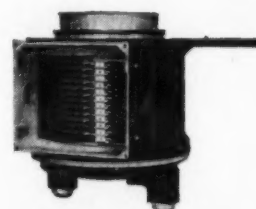
higher), shock (50 G or more) and vibration for use in missiles, ground and airborne computers, jet engine controls and similar applications requiring utmost reliability.—Hart Mfg. Co., 110 Bartholomew Ave., Hartford 1, Conn.

For more information circle 101 on inquiry card.

Critical
Military
Applications
demand:



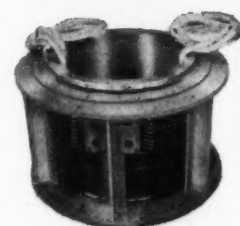
BREEZE SLIP RINGS



In circuitry where slip rings must function with dependable precision and stand up under difficult operational conditions, BREEZE slip rings will do the job.

From 2-ring to 500-ring assemblies . . . currents as high as 350 amps continuous at 220 volts and 700 amps overload at 220 volts. Special high voltage designs available; radio frequency assemblies . . . high speed rotation for thermocouple and strain gage applications. Also segmented ring assemblies for accurate sequencing and timing.

Consult us or write for detailed literature.



BREEZE BREEZE MARK
CORPORATIONS, INC.
700 LIBERTY AVE., UNION, N.J.

BREEZE PRODUCTS: ACTUATORS • HOISTS • TRANSMISSIONS • GENERATORS • STARTERS
STARTER GENERATORS • BELLOWS • SLIP RINGS • HOSE CLAMPS • HITEMP FLEXIBLE TUBING
For more information circle 46 on inquiry card.

INERTIA SWITCH

New SPDT inertia switch can be mounted to detect acceleration forces in any plane, and adjusted for equal



or unequal sensitivity in either direction along longitudinal axis. Standard units are factory adjustable from 1 to 3 G with special units to 50 G.

Reset is automatic.—The Magnavox Co., Dept. NP, Govt. & Ind. Div., Fort Wayne, Ind.

For more information circle 102 on inquiry card.

DIGITAL MOTOR

Bi-directional digital motor used to generate intermittent motion for pulsed cameras, can be programmed by tape to actuate many types of automated equipment, flight control, etc. Armature moves in direction of field magnetization and returns to center position when demagnetized.—Components Dept., Electronics Div., Curtiss-Wright Corp., 620 Passaic Ave., West Caldwell, N. J.

For more information circle 103 on inquiry card.

NEW-50% Smaller* HIGH-SPEED ROTARY SWITCH

MINIATURE SWITCH
SAMPLING and TELEMETERING

*New Design Concept
Fits into half the
space . . .

ONLY
3 1/2" x 3 1/2" x 3 1/2"

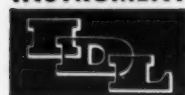
Exclusive IDL motor-within-commutator design makes possible this miracle of miniaturization.

- 2, 3 or 4 poles
- 45 BBM contacts per pole
- Pole speeds 20 rps
- To IRIG PDM standards

• TYPICAL APPLICATIONS
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BULLETIN #1024

INSTRUMENT DEVELOPMENT LABORATORIES



INCORPORATED

A Subsidiary of Royal McBee
Corporation

54 Mechanic St., Attleboro, Mass., U.S.A.

For more information circle 47 on inquiry card.

TYPE JL ROTARY SWITCH

meets MIL specification MIL-S-21604
and BuShips Drawing Number
9000-S6202-74422



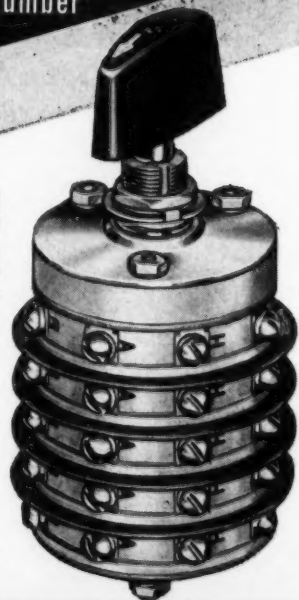
Maximum of
eight contact positions
and up to ten sections,
controlled by a
single knob.

Type JL rotary switch
provides unlimited rotation
in both directions. Move-
ment can be limited to any
number of eight positions
by two stop screws.

Designed for single-hole
panel mounting.

Electrical Rating:
5 amperes, 125 volts a-c.

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ESCO of WEYMOUTH

ELECTRO SWITCH CORPORATION

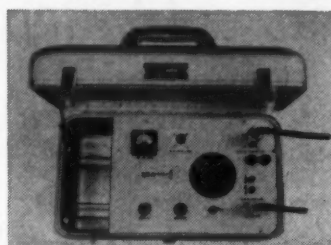
167 King Avenue, Weymouth 88, Massachusetts

For more information circle 48 on inquiry card.

New Products—CONT.

PORTABLE SYNCHRO TESTER

New Model TE-2A Synchro Test
Standard combining four rapid field
tests of aircraft synchro-transmitter/

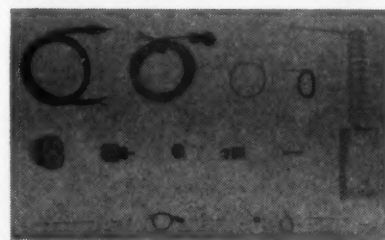


indicator systems, is housed in rain-
tight aluminum case. Connects at any
convenient point in series with 28v
400 cps synchro system to be tested.
Master Indicator has 3" dial accurate
to 0.5°; Master Transmitter has digi-
tal readout to 0.05°.—U. S. Gauge
Div., American Machine & Metals,
Inc., Sellersville, Pa.

For more information circle 104 on inquiry card.

TEMPERATURE SENSORS

New VECO Temperature Sensor
Assemblies incorporate reliable and
stable thermistors capable of detect-
ing changes less than 0.001°F. Easily

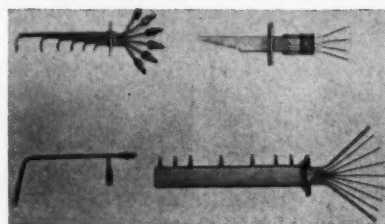


mounted by fasteners or taped, sol-
dered or cemented to surfaces for in-
flight telemetering from missiles,
satellites or aircraft. Bulletin SP31
is available.—Victory Engineering
Corp., 534 Springfield Rd., Union,
N. J.

For more information circle 105 on inquiry card.

TEMPERATURE & PRESSURE PROBES

Complete line of temperature and
pressure sensing probes and rakes



for total, static and pilot static pres-
sures, and with water-cooled tempera-
tures to 4000° is available or fabri-
cated to specs.—Instrument Div.,
Pemco, Inc., 5663 Brecksville Rd.,
Cleveland 31, Ohio.

For more information circle 106 on inquiry card.

DIFFERENTIAL PRESSURE SWITCH

New poppet-actuated SPDT switch
has positive action on low differential
pressures without chattering. No bel-

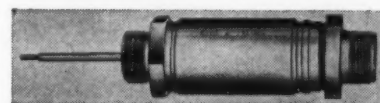


lows or diaphragms are used; high
reliability qualifies it for aircraft,
missile and military ground installa-
tions.—Consolidated Controls Corp.,
750 So. Isis Ave., Inglewood, Calif.

For more information circle 107 on inquiry card.

CONVERTER-TRANSDUCER

Kavlico converter-transducer pro-
vides dc output to replace potentiome-
ter where ac input is available, in
measuring, telemetering and control
applications. Advantages claimed are



no sliding contacts, infinite resolution,
high environmental resistance, high
linearity and sensitivity up to 200
volts/inch displacement. Temperature
range is -320° to 250°F.—Vinson
Eng. and Sales Co., 8044 Woodley
Ave., Van Nuys, Calif.

For more information circle 108 on inquiry card.

AC POTENTIOMETER

New "Vernistat" Model 3-B has
only 40-ohm output impedance with
a linearity within $\pm 0.01\%$, obtained
by combination of precision wire-
wound potentiometer and a precisely



tapped autotransformer in a BuOrd
size 18 housing. Uses 30 shaft turns
for full scale; minimum input im-
pedance at 400 cps is 50,000 ohms
with quadrature less than 0.1 mv/
volt.—Vernistat Div., Perkin-Elmer
Corp., Norwalk, Conn.

For more information circle 109 on inquiry card.

HIGH-TEMP SWITCH

New KLIXON high temperature
limit switch maintains operating
characteristics during long periods
as high as 800°F. SPDT contact rat-
ing of 5 amp 30 v dc resistive, is used



in missile, high temperature appli-
cations, or wherever extreme cor-
rosive conditions are present.—
Spencer Div., Metals and Controls
Corp., Attleboro, Mass.

For more information circle 110 on inquiry card.

GLASS CASE MINI POT

New wirewound "NEC-POT" mini-
ature potentiometer hermetically
sealed in all-glass case is 100%
humidity-proof, with all parts visible.



Supplied in 100-ohm to 30K-ohm
values with tolerances of $\pm 2\%$, to
operate over temperatures from
-55° to 225°C. Rated 2 watts at
85°C.—Networks Electronic Corp.,
14806 Oxnard St., Van Nuys, Calif.

For more information circle 111 on inquiry card.

RESISTANCE THERMOMETERS

New MH Series STIKONS, high-
temperature resistance thermometers,
with HYTEMCO grids and nickel
lead wires provide continuous opera-

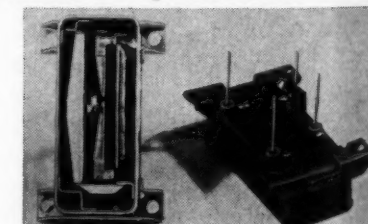


tion to 800°F, intermittent to 1000°F.
With proper bonding, time constants
are as low as 1/4 second.—Arthur C.
Ruge Associates, Inc., Hudson, N. H.

For more information circle 112 on inquiry card.

THERMAL TIME DELAY

New Type PT Thermal Delay Re-
lay for printed-circuit mounting in
missile use operates under vibration



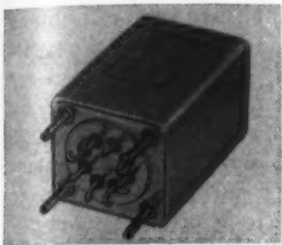
of 20 G to 2000 cps and shock of 50 G
for 11 ms to give factory-set delays
for periods from 3 to 60 sec. Ambient
temperature effects held to $\pm 5\%$
over the -65° to 125°C range. Specs
on request.—G-V Controls Inc., Okner
Pkwy, Livingston, N. J.

For more information circle 113 on inquiry card.

MILITARY SYSTEMS DESIGN

MINI POWER RELAY

New Model 26S20 hermetically sealed miniature DPDT relay has rated life of 100,000 operations at 25



amp, 115 v ac resistive; only 1 1/2" x 1 1/2" x 2 11/16" high.—Kurman Electric Co., Div. Norbute Corp., 191 Newel St., Brooklyn 22, N. Y.

For more information circle 114 on inquiry card.

KEYBOARD TYPE SWITCH

New 6-Pole Keyboard Switch is available in either Push On-Push Off or Momentary style with any com-

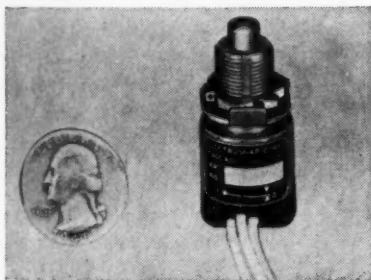


bination of normally-closed, normally-open contacts rated at 1/2 amp at 28 v dc.—Pendar, Inc., Switch Div., P. O. Box 3355, Dept. D., Van Nuys, Calif.

For more information circle 115 on inquiry card.

PUSH-BUTTON SWITCH

Miniaturized environment-free sealed push-button switch combines corrosion resistant materials and moisture-proof construction. Rated 6



amps 125 v ac/30 v dc resistive; operating force of 8 to 12 lbs enables SPST switch to break ice or dirt coatings on plunger.—Electrosnap Corp., 4220 W. Lake St., Chicago 24, Ill.

For more information circle 116 on inquiry card.

METAL CONSOLES

New Prem-O-Pak Console cabinets for modular console systems can be provided in variety of arrangements, including sloping cabinets, desk tops and pedestals, turrets and sliding drawers.—Premier Metal Products Co., 337 Manida St., New York 59, N. Y.

For more information circle 117 on inquiry card.

thanks to
XEROGRAPHY...



Robert Harding, right, assistant chief engineer of Arma division, American Bosch Arma Corporation, points out to Frank McShane, cost-improvement expert, the high quality and contrast of an 11"x17" stock print reduced from an original 22"x34" drawing. The print is a sample of many run off on an offset duplicator from an inexpensive offset paper master prepared xerographically by Xerox Model 1218 copying equipment.

ARMA SAVES \$82,000 YEARLY

...reproducing

- engineering drawings
- drawing-change notices
- specifications sheets
- parts lists

Arma Division, American Bosch Arma Corporation, is saving \$82,000 a year in the rapid reproduction of engineering drawings, drawing-change notices, specification sheets, and parts lists. Arma manufactures midget brains for missiles and other intricate electronic devices.

The \$82,000 economy results from the installation of Xerox® Model 1218 copying equipment and offset duplicating to supplant conventional drawing-reproduction methods.

Xerox Model 1218 copying equipment, operating on the principles of

xerography—clean, fast, dry, electrostatic—prepares inexpensive offset paper masters from original engineering drawings of A to D size.

The larger drawings are reduced with fine legibility to 12"x18" masters, from which multiple prints are quickly run off on offset duplicators.

The quality of copies is superb. Yet, prints cost so little that engineers are encouraged to discard them after use, rather than re-file them.

Drawing-change notices now reach production lines and suppliers faster than ever before.

For more information circle 49 on inquiry card.

An Arma engineering library of expendable drawings provides prints, run off in advance of actual need, for engineers' self-service availability.

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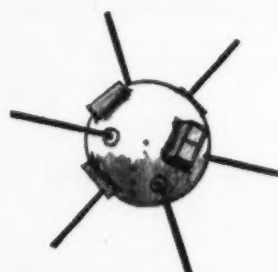
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- ✓Resistance strips for temperature gauges
- ✓Erosion gauges*

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- ✓Interference films for Infrared
- ✓Anti-static coatings



*Metavac Resistance Strip used by Naval Research Laboratory on Vanguard Satellite to measure erosion caused by Meteor contact.

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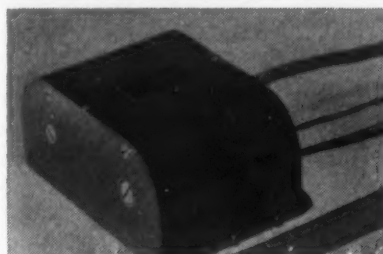
45-68 162nd Street
Flushing 58, New York
Hickory 5-0400

For more information circle 50 on inquiry card.

New Products for Missile Instrumentation

MISSILE RECORDER

New Model 820G Event Recorder records 21 channels "on-off" information on 100 ft electrosensitive paper chart 3 15/32" wide. Records in any

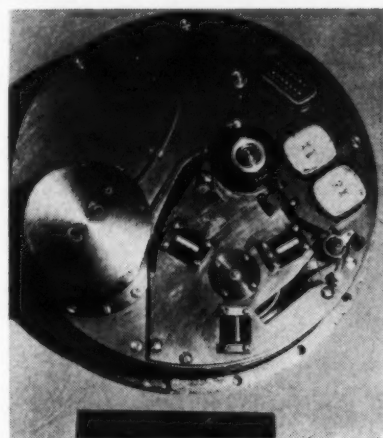


position at speeds from 1 to 8 ips under high shock and acceleration of missile firing.—Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, Ohio.

For more information circle 118 on inquiry card.

CLOUD COVER RECORDER

Basic tape recorder for Satellite use is only 5 1/2" wide, uses 75-ft endless loop cartridge in recording cloud



pictures and communications, for retransmittal when interrogated from earth.—Minnesota Mining & Mfg. Co., 900 Bush St., St. Paul 6, Minn.

For more information circle 119 on inquiry card.

THREE-SPEED MOTOR

Enclosed explosion-proof 24 v dc centrifugally-governed 3-speed motor for military camera and tape applications is rated at 0.1 hp at 1920,

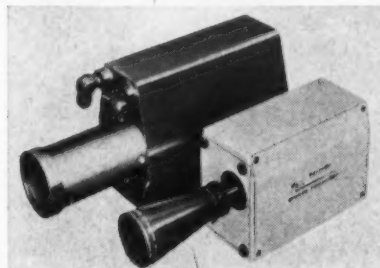


1440 and 960 rpm with ±1% variation. Adaptable to customer requirements.—Western Gear Corp., Electro Products Div., 132 West Colorado St., Pasadena, Calif.

For more information circle 120 on inquiry card.

HIGH TEMPERATURE CAMERA

New HS-16WJ camera is used in gathering shock and vibration data in vicinity of rocket nozzles during static firings at Edwards AFB. Surrounded by a stainless steel water jacket, and with lens protected by a



stainless-steel tube with safety plate glass, a modified HS-16B reduced in size and film capacity, but incorporating standard correlation switches and footage counter, withstands temperatures estimated at 5,000°F and velocities in excess of Mach 2. The new camera and water jacket are shown.—Benson-Lehner Corp., 11930 W. Olympic Blvd., Los Angeles 64, Calif.

For more information circle 121 on inquiry card.

EXPOSURE METER

New HS3201 reflectance exposure meter for high-speed photography gives pin-point reading by sighting on subject. Dial reading for 2° field is given by operation of high- or low-

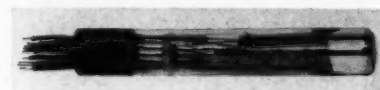


range button on meter. Aperture setting is read directly from ring scale, preset to film speed.—Industrial Prod. Div., Fairchild Camera and Instrument Corp., Robbins Lane, Syosset, L. I., N. Y.

For more information circle 122 on inquiry card.

SMALL DIAMETER PHOTOTUBES

Two new 3/4" diameter multiplier phototubes for space vehicle and other cramped-space applications have performance characteristics equal to



large tubes. Type 6362 uses silver magnesium dynodes for max stability at high voltages; Type 6935 with cesium antimony dynodes features high gain at low voltages. Technical specs on request.—Electronics Tube Sales Dept., Allen B. DuMont Labs., Inc., 750 Bloomfield Ave., Clifton, N. J.

For more information circle 123 on inquiry card.

Design Parameters of Ferrac Magnetic Amplifiers

IMPEDANCE PARAMETERS.—Push-pull polarity reversible magnetic amplifiers of the instrument type should be defined and discussed as are other active circuit elements such as transistors and vacuum tubes. Just as transistors are characterized by hybrid parameters (β) and vacuum tubes by conductance parameters (g_m), the appropriate parameters of a magnetic amplifier as a current input, voltage output device are contained in its impedance matrix.

One property enjoyed by magnetic amplifiers besides unlimited life and indestructibility is the complete isolation between all terminal pairs. To utilize this, Airpax magnetic amplifiers are supplied with two input windings for flexibility in feedback and signal mixing. At DC there is no interaction between the two inputs. Also, unlike transistors, the magnetic

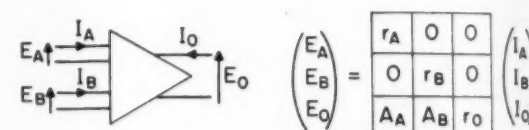


FIG. 1. IMPEDANCE MATRIX of Ferrac Amplifier.

amplifier is a perfectly unilateral device with no reverse transconductance, that is, current and voltages at the output are not reflected to the input. Our impedance matrix takes the form of Fig. 1 where:

- r_A = open circuit input resistance of winding A.
- r_B = open circuit input resistance of winding B.
- r_O = output resistance.
- A_A = open circuit transresistance of winding A (output voltage per unit input current).
- A_B = open circuit transresistance of winding B.

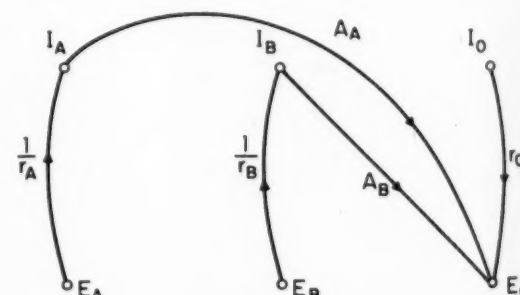


FIG. 2. SIGNAL FLOW Graph.

The signal flow graph² of Fig. 2 shows the necessary relationships in perhaps the simplest language of linear feedback analysis.

LINEAR RANGE.—These new FERRAC amplifiers are voltage limited. Their linear range (all types in this series) is ±10 v at their normal load of 1K. Saturated output at 1K load is approximately ±15 v and the maximum output (full saturation, no load) is

² "Feedback Theory—Some Properties of Signal Flow Graphs," S. S. Mason, Proceedings of the I.R.E., September, 1953.

about ± 25 vdc. Due to signal mixing within the amplifier at its output, the output cannot be replaced by a simple Thevenin equivalent circuit especially with respect to linear range. In Figure 3 the useful

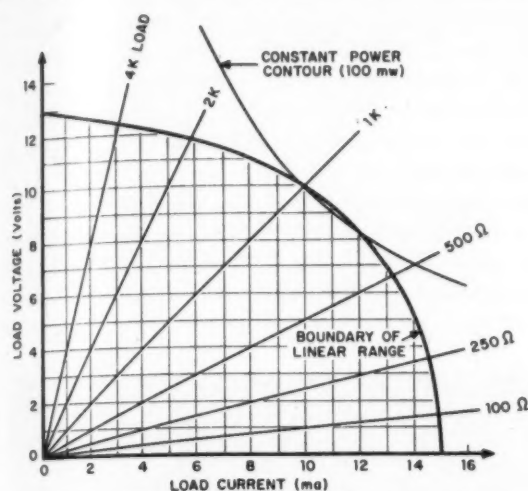


FIG. 3. FERRAC AMPLIFIER Load Lines.

output current or voltage linear range is shown in the I_o, E_o plane. Into an open circuit, the linear range, defined as a 5% departure, is 13 v and into a short circuit the linear current range is 15 ma. Maximum power within the linear range occurs as shown at 10 v, 10 ma on a 1K load.—(From new 4-page Technical brochure describing 400-CPS FERRAC Amplifier.—Airpax Electronics, Inc., Ft. Lauderdale, Fla.)

For this literature circle 124 on inquiry card.

New Meter Principle

Elimination of hairsprings, jewels and pivots, the most fragile elements of a conventional meter system, is accomplished in a new meter designed for Super-Sensitive Laboratory Instrument (Class 0.5) applications. Sensitivities to as low as 2 microamperes full scale are combined with overload capabilities up to 5 times full scale indefinitely, and ability to withstand surges up to 300 times normal current.

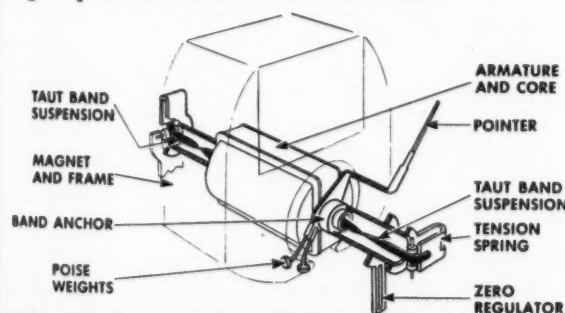


FIG. 1. NEW SUPERSENSITIVE METER suspension principle gives rugged reliability, higher accuracy to lab meters.

The new taut-band suspension system is available in a wide range of meter types; including 100° arc-angle, 250° arc-angle, ac iron vane, ac dynamometer, D'Arsonval, and in all panelboard style housings as well as switchboard and portable styles.—(From new 4-page Brochure, The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio.)

For this literature circle 125 on inquiry card.

BACK-PACK-TV

New 4-lb. "Tele-Tran" camera and 12-lb back-pack transmitter is a completely transistorized TV system



operating in the 1300-1900 mc band, and having range of $\frac{1}{2}$ mile. Completely automatic operation includes automatic light level compensation at camera.—Dage Television Div., Thompson Ramo Wooldridge, Inc., Michigan City, Ind.

For more information circle 126 on inquiry card.

DOVAP FILTERS

New Model 354 crystal filters for the 37mc range achieve RF system

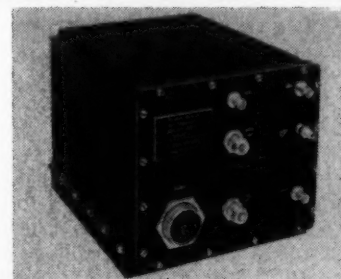


selectivity in DOVAP Doppler missile locator system (See article, "Missile Range Instrumentation" this issue) to prevent false triggering. Technical Bulletin on request.—Hycon Eastern, Inc., 75 Cambridge Pkwy, Cambridge 42, Mass.

For more information circle 127 on inquiry card.

MISSILE BEACON

High-power and sensitivity feature new S-band decoder type guided missile beacon, Model SRTS-2003CH, developed to work with advanced radars using coders such as KY-94/



GPA, but can be modified to meet other requirements. Developer also will supply information on related missile and drone problems.—Telrad Mfg. Corp., 1440 Broadway, New York 18, N. Y.

For more information circle 128 on inquiry card.

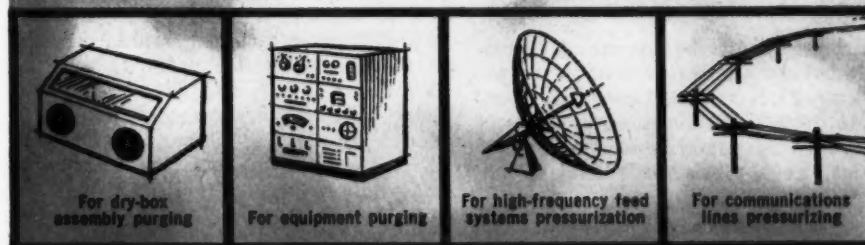
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For more information circle 51 on inquiry card.

New Products—CONT.

TELEMETER RF AMPLIFIER

Model A-25 power amplifier, to extend telemetering transmitter range in 215-260 mc band, supplies 25 watts

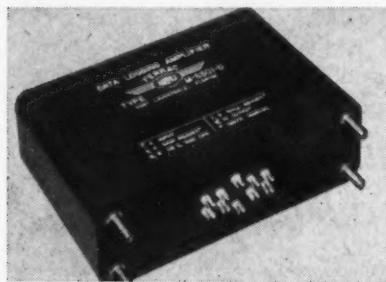


output from 2-watt input. Primarily designed for FM or PM systems, is also adaptable for AM with slightly reduced output. Meets high environmental missile conditions, weighs only 1.5 lbs.—*Dorsett Labs., Inc., 401 East Boyd, Norman, Okla.*

For more information circle 129 on inquiry card.

MAGNETIC DATA AMPLIFIER

New Type M-5301-D Magnetic Data Logging Amplifier is a three-stage, molded magnetic differential amplifier for use with thermocouple,



strain gage and other dc transducers. Performance similar to that of chopper amplifiers; voltage gains of from 100 to 10,000 are obtained by use of external resistors.—*Airpax Electronics, Inc., Seminole Div., Fort Lauderdale, Fla.*

For more information circle 130 on inquiry card.

LUMPED CONSTANT DELAY

Model F341 lumped constant delay line for data conversion has 300 ohms

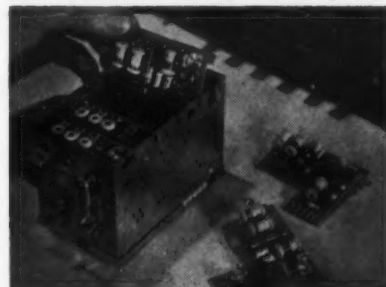


impedance with rise time of 0.15 μ sec. Total delay is 2.4 μ sec, tapped at 0.8 and 1.75 μ sec. Built to MIL-specs, is $\frac{3}{8}$ " x $1\frac{1}{8}$ " x 5".—*Control Electronics Co., Inc., 10 Stepar Place, Huntington Station, N. Y.*

For more information circle 131 on inquiry card.

TRANSISTORIZED VHF CONVERTER

New Model HLH-103-1 transistorized converter, a component of the Signal Vehicular Radio Communications System (AN/VRC-12), provides continuous tuning from 20-76 mc in two bands with 4.2 turns per band. Modular design and printed



circuitry is used for quick repairability. A frequency control system using variable-capacity diodes provides excellent pull-in range at all frequencies, and LO stability is ± 130 kc max over the temperature range from -40° to 85°C .—*P. R. Mallory & Co., Inc., 3029 East Washington St., Indianapolis 6, Ind.*

For more information circle 132 on inquiry card.

L-BAND ANTENNA

Telemetry antenna for 1400 mc telemetry band designated Model 9955 provides all-metal leading edge of

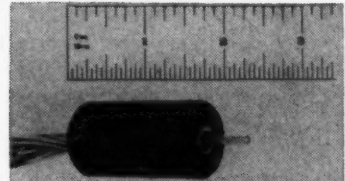


high aspect ratio for minimum drag with body of high-temperature plastic or ceramics. Polarization is perpendicular to mounting surface with circular radiation pattern, with a VSWR of 1.5 over a 25% frequency band. Scaled versions also available for UHF, S and C bands.—*Canoga Div., Underwood Corp., 15330 Oxnard St., Van Nuys, Calif.*

For more information circle 133 on inquiry card.

MICRO AN-DIG ENCODER

Model AD11-13 Analog-Digital shaft encoder for airborne use is only 1.062" diameter, yet converts



analog inputs to 13-bit information, eliminating ambiguity by V-scan brush arrangement and internal isolation diodes.—*Litton Industries, Components Group, 5873 Rodeo Rd., Los Angeles 16, Calif.*

For more information circle 134 on inquiry card.

SUPER VIDEO AMPLIFIERS

Two M-630 (60 db gain) or two M-680 (20 db gain) video amplifier sections are used with a common power supply in a single case. The two

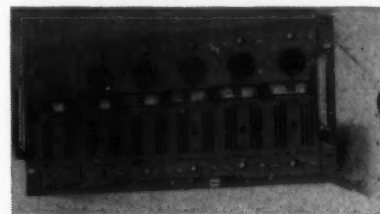


sections can be used separately, in cascade, in parallel or in push-pull operation (for scope deflection) for versatile instrumentation applications.—*Instruments for Industry, Inc., 101 New South Road, Hicksville, N. Y.*

For more information circle 135 on inquiry card.

"GROUND-NOISE-LESS" AMPLIFIER

Model 114A Differential DC Amplifier for transducer inputs has very high common-mode rejection to eliminate noise and spurious pickups. Six Amplifiers shown each contain two chopper-stabilized amplifier circuits,

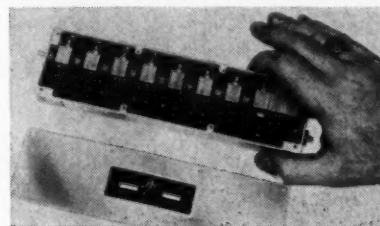


transistorized except for output tubes, and electrostatically shielded from each other. Output and input can be floated up to 250 v difference in potential.—*Kin Tel Div., Cohu Electronics, Inc., Box 623, San Diego 12, Calif.*

For more information circle 136 on inquiry card.

TRANSISTORIZED IF AMPLIFIERS

New completely transistorized T-300 Series IF amplifiers for radar, telemetry, computer and custom communications equipment are available



in T-330A (80 db gain, 10 mc bandwidth) and T330B (100 db gain, 3 mc bandwidth) models. All interstages are shielded with printed circuit board acting as ground plane. All applicable MIL-Specs are met.—*Instruments for Industry, 101 New South Rd., Hicksville, N. Y.*

For more information circle 137 on inquiry card.

Solder Joint Inspection Improves Reliability

Wherever solder joints are used, possibility of failure is an important factor in reliability. At Dressen-Barnes, Pasadena, California, a thorough inspection of each solder joint on every DC Power Supply produced has improved reliability by an impressive factor. Failure due to imperfect solder joints has been reduced to virtually zero.

The Dressen-Barnes solder joint inspection procedure has been nicknamed the "red-dot" check because each joint is painted with a RED DOT after the following three part inspection:



RED-DOT TECHNICIAN paints red dot on solder joint after giving it careful 3-way inspection prior to electrical tests and run-in operation.

PHYSICAL CHECK:

Each solder joint is physically checked by manipulating the wires terminating at the joint. Any looseness existing or developing as a result of the check is cause for rejection.

OPTICAL CHECK:

If the joint passes the physical check, a powerful hand magnifying glass is used to inspect the joint for porosity and form.

COLOR CODE CHECK:

Incorrect wiring is not always immediately apparent from bench tests or proper run-in checks. For this reason, at the "red-dot" stage, the color coding of wires terminating at each joint are checked by the red-dot technician against the production wiring diagram.

Experience has proved to Dressen-Barnes that the cost of the detailed red-dot check is largely offset by

MILITARY SYSTEMS DESIGN

savings realized at the final test and run-in inspection. By catching all wiring errors and all less-than-ideal solder joints before bench tests, the testing time has been cut appreciably, and the failures showing up during the rigorous run-in operation have been substantially reduced. Thus, both testing time and the number of rejects beyond production have been cut, proving the importance of solder joint inspection before shipment.

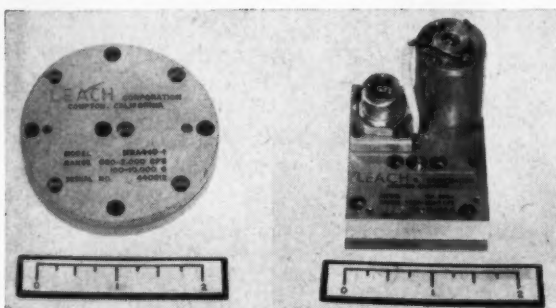
Reliability is improved because long-time failures due to deterioration of joints and component failure due to wiring errors of limited immediate electrical significance are eliminated by this "before test" inspection. The record of continued performance of Dressen-Barnes DC Power Supplies after delivery helps keep costs low by eliminating factory rework of delivered equipment.

(Copies of Dressen-Barnes "Operating Procedure For Solder Joint Checks" are available upon request.—Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena 8, Calif.

For this literature circle 138 on inquiry card.

Accelerometers are Self-Contained Recorders

Two self-contained recording accelerometers for use in studies of water-entry shock, ground impact or explosion blast, and rocket sled accelerations, have been developed by the Inet Division, Leach Corporation, Compton, Calif. The Multiple Recording Accelerometer, Model MRA-440 (left) contains eight tuned sensing elements which measure and record the shock re-



MULTIPLE RECORDING ACCELEROMETER (left) contains eight tuned sensing elements. Triaxial Recording Accelerometer (right) has three elements oriented in mutually perpendicular planes.

sponse spectrum of the motion to which it is subjected. It weighs only 2 ounces.

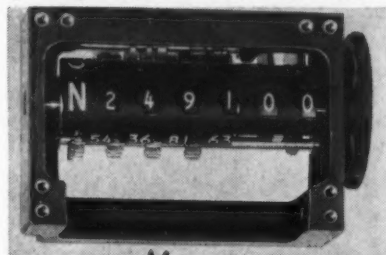
The Triaxial Recording Accelerometer TRA-200, (right) has three sensing elements arranged mutually perpendicular which directly sense and record all data concerning the acceleration-time history of its motion along each of its axes. The TRA weighs six ounces.

Neither of the models require connection to external devices for readout, although the TRA requires external power proportion. Because of their small size, both can be installed in nearly any desired location in a missile.

For more information circle 139 on inquiry card.

PRECISION COUNTER

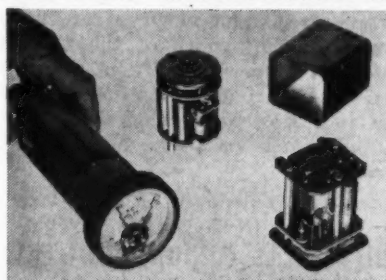
Series 2500 high-precision mechanical counter for military and telemetering applications features operating speeds to 1350 rpm, low starting torque (0.5 oz-in) and can be



supplied with servo-operated readin and readout.—Chicago Dynamic Industries, Inc. Precision Prod. Div., 1725 Diversey Pkwy, Chicago 14, Ill. For more information circle 140 on inquiry card.

METER-RELAY CONTROL UNITS

New miniaturized meter-relay controls with self-contained power supplies are available in ruggedized limit-control and automatic-control cir-

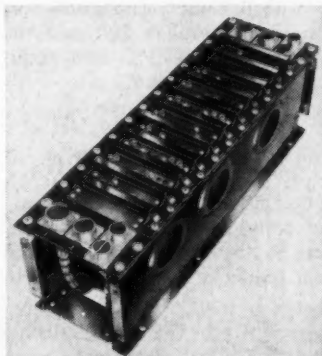


cuits in both rectangular and round, ac and dc models, for missile ground support equipment.—Assembly Products, Inc., Chesterland, Ohio.

For more information circle 141 on inquiry card.

SIGNAL CONDITIONER

Magnetic Signal Conditioning system for telemetering and other data-collection and processing applications features versatility and flexibility in a modular construction. Lightweight aluminum frames accommodate from



one to several hundred modules of equal size and appearance. Modules available at present are: Power Supply Regulator, Vibration Amplifier, Carrier-Amplifier, DC Amplifier (0 to 2 cps) and DC Amplifier (0 to 100 cps).—Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.

For more information circle 142 on inquiry card.

GENERAL ELECTRIC

VOLTAGE REGULATION

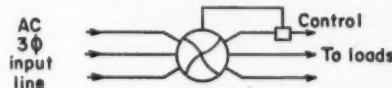
IDEA FILE

By C. A. NEUMANN

FOR RADAR ENGINEERS

General Electric Inductrol* regulators keep radar systems on the air effectively and accurately

Automatic control requirements for correcting voltage fluctuations are encountered in all portions of a radar system. Control can be handled by Inductrol regulators at the input to each component of the system, at the input of a group of components, or at the input to the entire system. Inductrol voltage regulators can also supply run-up voltage or current where required.



AN INDUCTROL REGULATOR controlling incoming voltage fluctuation in a three-phase circuit is shown in the above diagram. The three-phase regulator corrects each phase of the system concurrently and by the same amount.

Where phase voltage unbalances create operational difficulties by introducing ripple in the d-c power supplies, individual line control with single-phase regulators will correct these unbalances. They can be installed on any portion of the system.

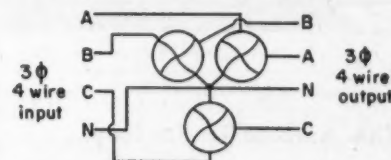
THREE SINGLE-PHASE INDUCTROL VOLTAGE regulators are connected line-to-neutral on a four-wire, three-phase system in the diagram below. Each regulator will control a phase of the system independently of the others—thus making available a balanced three-phase voltage output regardless of existing load unbalances.

As an example, power feeding a radar system requires regulating equipment to correct for incoming voltage variations of $\pm 15\%$, and maintain a constant input voltage to the system within a bandwidth of $\pm 1\%$. Load—500 kva, balanced three-phase; system voltage—480 volts, 60 cycles. Requirements: maintain a constant voltage

*Registered Trademark of General Electric Co. for Induction Voltage Regulators.

output of 480 volts, $\pm 1\%$. Installation is at a remote location. Regulating equipment must not require maintenance and its controls must be "drift-free."

To meet this requirement, the General Electric Inductrol regulator will correct for incoming line variations from 408 volts to 552 volts. Using basic formulae, we determine the load current to be 600 amps and that the regulator will have an 87.5 kva rating and a range of $\pm 17.5\%$.



PHASE UNBALANCE REQUIREMENTS are not involved in this example so a three-phase regulator will be sufficient.

The Inductrol regulator has no sliding contacts to wear, is of rugged construction, and will perform its intended function with the greatest degree of reliability. Its associated controls are drift-free, and are temperature and frequency compensated. They require no attention after the original setting has been made.

The regulator selected for this example is a dry-type suitable only for indoor service. Liquid immersed units are available for outdoor service.

OTHER INDUCTROL REGULATOR USES: power supply voltage control, control of filament power supplies, focus coil control, and grid voltage control in radar systems; variable speed antenna drives, computers, and many other electronic equipments.

For more information write to Section 425-21, General Electric Company, Schenectady 5, New York.

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For more information circle 52 on inquiry card.

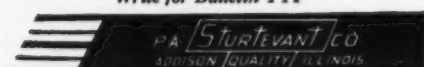


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Capacities:
(0-200 in. lbs.) or
(0-150 ft. lbs.)

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For more information circle 53 on inquiry card.

The Automatic Factory

by June, et al. . . a fresh viewpoint on what "manless factories" can be . . . free from the generalities, and misconceptions so prevalent on this subject. Cloth, 88 pages, 1955. \$1.50

Nuclear Reactors for Industry and Universities

Edited by Ernest H. Wakefield. Covers types, availability, operation, protection, control, experiments, legal aspects, and detailed cost study. 1954. cloth, 92 pages. \$2.00

Heat Inertia Problems of Automatic Control of Temperature

by Victor Broida, based on the concept of "fictitious mass" of heating process unit under automatic control. 1950. paper, 5 1/4" x 8 1/4", 61 pages. \$1.00

The Electronic Control Handbook

by R. R. Batcher and William Moulic. Presents electrical and electronic principles applicable to measurement and automatic control. 1946. paper, 244 pages. \$2.00

INSTRUMENTS PUBLISHING CO.
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PULSE GENERATOR

High-speed double-pulse generator producing two identical pulse trains with repetition rates from 1 cycle to 10 mc in seven ranges, has

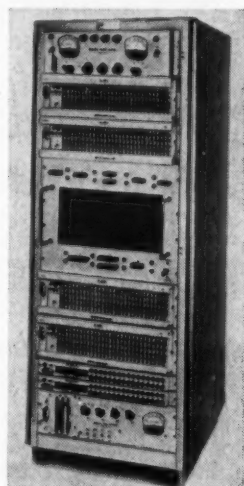


provision for individual delay of both pulses. Output pulses are also adjustable in width from 20 milliseconds to 12.5 μ sec with rise and fall times of less than 8 milli- μ sec. Brochure on request.—Rutherford Electronics Co., Culver City, Calif.

For more information circle 143 on inquiry card.

RANDOM ACCESS CORE MEMORY

Model TGM all-transistor, coincident current, ferrite core random access magnetic core memory with 8 μ sec cycle time, is designed for use



with 3C T-PAC systems or any other digital system requiring high-speed random access. Word capacities up to 4096 and word lengths to 40 bits are readily assembled due to modular construction.—Computer Control Co., 92 Broad St., Wellesley, Mass.

For more information circle 144 on inquiry card.

BUFFER STORAGE

New sequential-to-sequential Buffer Storages, based on coincident-current magnetic elements, implement digital data transfer between systems that are asynchronous or have different data ranges. Operates at any loading and unloading rates from 0 to 200,000 characters/sec, loaded serial-

ly, in parallel, or in any serial-parallel combination. Capacity up to 4032 characters in standard units, with 4 to 12 bits per character.—DI/AN Controls, Inc., 40 Leon St., Boston 15, Mass.

For more information circle 145 on inquiry card.

IN-LINE DISPLAY

New In-Line Display features numbers of uniform size and intensity, and excellent readability. All wiring

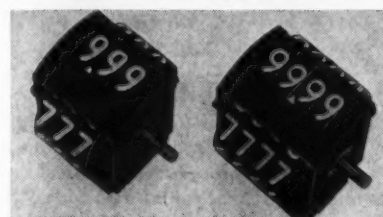


is at the rear of the unit for ease in installation. Voltage is 6 to 7.5 vac. Single units are available which can be assembled in groups of 2, 3, 4, etc., as required. The viewing screen extends the full width of the unit, so that the final assembly of a group presents a continuous surface.—Industrial Electronic Engineers, Inc., 3973 Lankershim Blvd., North Hollywood, Calif.

For more information circle 146 on inquiry card.

INTERNAL PINION COUNTER

New Model 10322 counter designed for digital display on airborne fuel flow indicators, navigational and dead

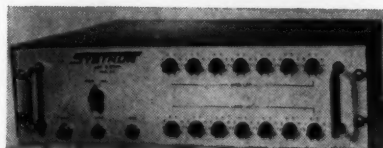


reckoning equipment is available in 3- or 4-digit styles. Designed for continuous operation at 300 rpm.—Bowmar Instrument Corp., 8000 Bluffton Rd., Fort Wayne, Ind.

For more information circle 147 on inquiry card.

LIMIT DETECTOR

Model 1470 Systron Digital Detector provides "Low-Go-High" indications to any exact number of counts by two banks of presettable switches.



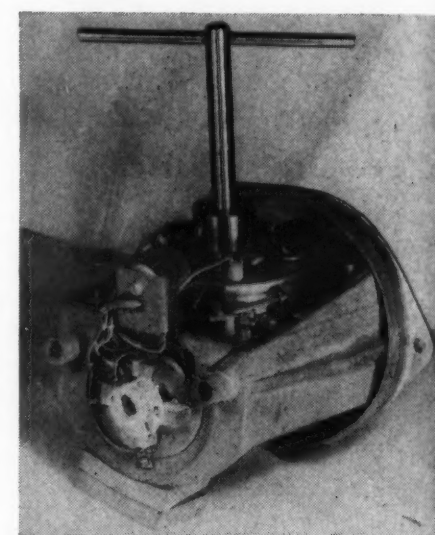
For use with any Systron counter to provide Alarm, Digital Control, or measurement classification, from 1 to 10 digit limits.—Systron Corp., 950 Galindo St., Concord, Calif.

For more information circle 148 on inquiry card.

Spring Driven Displacement Gyro

Many missiles, including torpedoes, require accurate, simple and reliable inertial guidance elements. The maintainability and reliability of such elements are considerably complicated for a gyroscope by the provisions needed to bring the gyro rotor up to its operating speed. One solution is the spring-wound Gyro, Type G-180, developed by the Whittaker Gyro Division of Telecomputing Corp., of Van Nuys, Calif.

The Type G-180 Gyroscope (See Figure) is a simple yet reliable instrument which can be placed in operation in a very short time. It can accelerate to its top speed of 10,000 rpm and become operable in less than 0.1 second to provide accurate gyroscopic performance for periods of over one minute. Useful life with some degradation of performance can be obtained for longer periods of time inasmuch as the coast time of the rotor exceeds 10 minutes.



SHORT-TIME INERTIAL Guidance Gyro is spring-wound, can be stored for long periods, is operable in 0.1 second.

The new gyroscope is a conventional free gyro insofar as the gimbal system and the signal generator are concerned, but departs from conventional designs in its motive power. A novel springmotor, which previously has been hand-wound, is used to accelerate the rotor to operating speed whereupon it disengages itself from the rotor, allowing the spinning wheel to coast during the useful life of the instrument.

The rotor utilizes inner rotation, angular-contact ball bearings and an extension of the shaft serves the dual purpose of coupling to the spring-accelerating motor and also of caging the instrument. The spring housing is located external to the gimbal system, being mounted on the same frame.

Caging is performed manually; the gimbal being rotated by hand until the shaft rotor is aligned with coupling, whereupon the mechanism is engaged and the winding tool inserted. The hand-held winding tool engages holes in a ratchet device and energy is stored in the spring by rotating the tool. The winding opera-

MILITARY SYSTEMS DESIGN

tion continues as the ratchet holds the mechanism from releasing. When approximately 40 in-lbs of torque are applied, an armed indication switch is closed to indicate that the spring is fully wound. Further application of torque will rotate the mechanisms no more than one ratchet notch where it meets a mechanical stop which prevents spring overwinding.

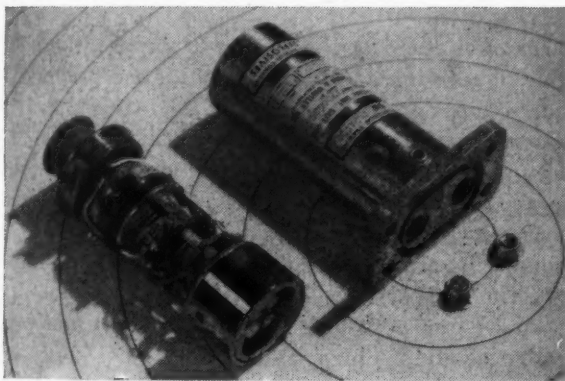
Two methods for unlatching the spring mechanism are available. Either burning a fuse wire, or on other models, the energizing of an electrical solenoid, releases a spring-loaded plunger which delivers a hammer blow to the ratchet pawl. The energy of the wound spring is thereupon transferred through the coupling to the rotor which is accelerated rapidly. When the top speed has been reached, the coupling is automatically disengaged and retracted from the gimbal. Full gimbal freedom and gyroscopic performance is then realized.

The outer gimbal can be equipped with either a potentiometer or a commutator. Electrical connector, potentiometer values and gyro mounting can be supplied to satisfy customer requirements.

For more information circle 149 on inquiry card.

Ordnance Arming Device Telemeters its Condition

A new Explosive Initiator, designated the Beckman & Whitley Model 2152A, based on the action of an indexing rotary solenoid which controls the position of an out-of-line disk rotor between the initiating element and the final igniting charge, meets military type safety and arming device requirements.



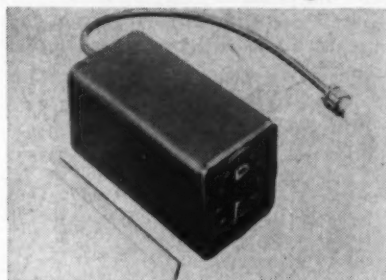
Upon reception of a remotely originated "arm" command, the rotor is positioned to permit a subsequent firing command signal. At any time before firing, reception of a "safe" command turns the rotor to make initiation impossible. Switching and circuitry provide for telemetering the "safe" and "armed" condition of the initiator. Also, a visual indication of this condition is displayed on the body of the unit.

In addition to missile and drone applications, it also facilitates the remote control of land-based military and industrial explosives. The Model 2152A is $4\frac{1}{2}$ " x $1\frac{3}{4}$ " dia, weighs 1 lb, and utilizes a bayonet-type 11-pin electrical connector. It is a product of Beckman & Whitley, Inc., San Carlos, Calif., also a leading producer of explosive-operated devices.

For more information circle 150 on inquiry card.

BALANCING POTENTIOMETER

New Autopot Series EMP-NS2 is a self-balancing potentiometer for accepting outputs from thermocouples or other transducers in flight test-



ing. Available in 25 pyrometer and 14 millivoltmeter standard ranges with automatic ambient temperature compensation. Minimum readable input is 30 μ v.—Daystrom Pacific, 9320 Lincoln Blvd., Los Angeles 45, Calif.

For more information circle 151 on inquiry card.

SILICON SOLAR MODULES

High-efficiency silicon solar battery modules capable of direct replacement for dry cell and mercury cell applications are now available. Each SM5-1020B module (see illustration) may be used for each 1.5 volt dry-cell battery, and using as many parallel strings as required to supply the necessary load current.

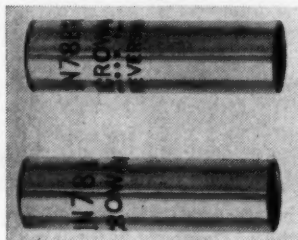


Each module will supply a load current of approximately 35 ma in direct sunlight. Silicon-solar batteries may be teamed with sealed nickel cadmium storage units to provide continuous day-and-night power.—International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

For more information circle 152 on inquiry card.

COAXIAL SILICON DIODES

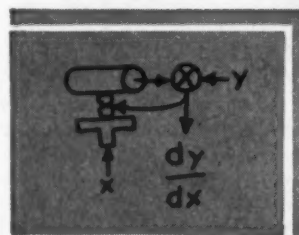
1N78B and reversed polarity 1N78BR coaxial microwave silicon mixer diodes replace 1N78A and



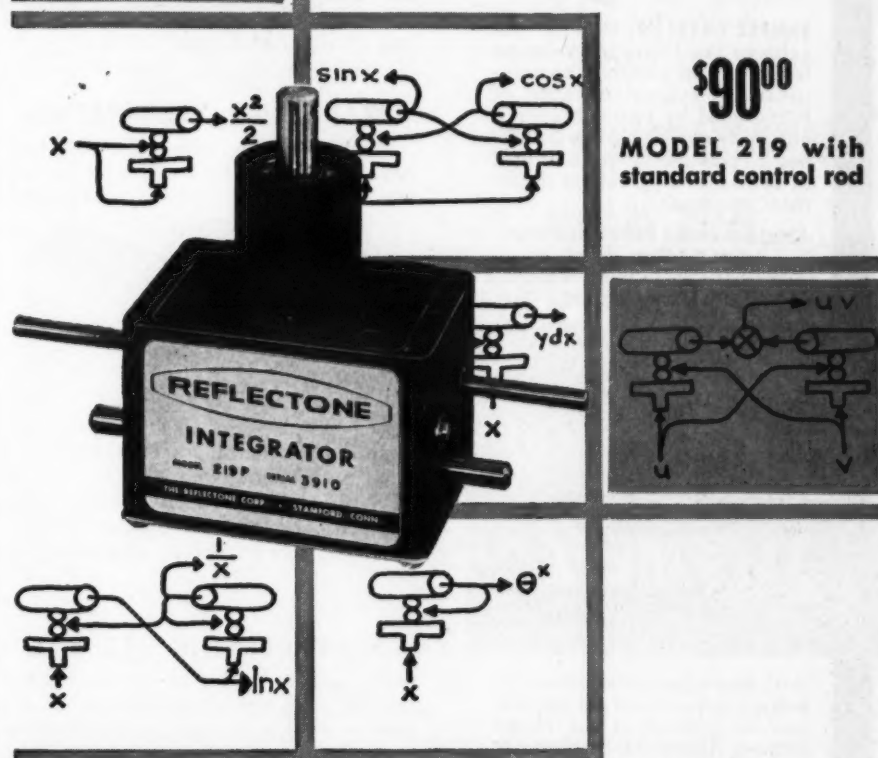
1N78AR diodes, providing improved noise figure for receivers in 12.4-18.0 kmc range.—Microwave Associates, Inc., Burlington, Mass.

For more information circle 153 on inquiry card.

HIGH-PRECISION BALL AND DISC INTEGRATORS



Highest accuracy and reproducibility for automatic control and computing systems. Smooth, reliable operation for precise speed control and accurate integration of variables such as flow, strain or position. Low-cost, compact, flexible design element. No lubrication required.



\$90⁰⁰

MODEL 219 with standard control rod

TYPICAL APPLICATIONS

NAVIGATION SYSTEMS • FLOW TOTALIZERS • PRECISION SPEED CONTROL • PLANIMETERS • TACHOMETERS • CONTINUOUS WEIGHING DEVICES • STRAIN ANALYSIS • INFRA-RED SPECTROPHOTOMETERS • PROCESS CONTROLS

SPECIFICATIONS:

Accuracy: $\pm 0.1\%$
 Reproducibility: $\pm 0.01\%$
 Output Torque: 3 oz.-in. (higher outputs at reduced accuracy)
 Input Torque: 2 oz.-in. (no output load)
 Control Rod: Vernier, rack, screw, or plain
 Special rods designed to specification
 Control Rod Force: 3 oz. static 1 oz. dynamic
 Backlash: 8 minutes at 2 oz.-in. and $\frac{1}{2}$ inch control rod displacement
 Input Speed: 0-750 rpm
 Output Speed: Reversible up to more than twice the input

Additional mechanical specifications and applications data available on request.

REFLECTONE

THE REFLECTONE CORP. • STAMFORD, CONNECTICUT

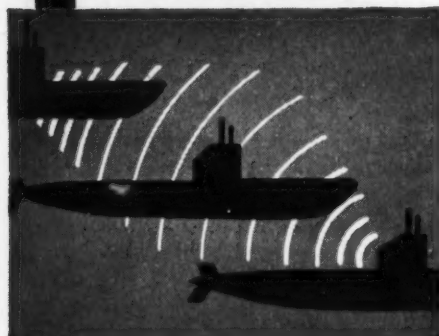
For more information circle 55 on inquiry card.

Engineers, D&D

Translate Non-Classical Techniques Into Advanced Underseas Warfare Systems

SAMPLE PROBLEM: How do you achieve maximum information transfer in an undersea communications system capable of being used by two submerged missile-firing submarines—without a third submarine stationed in between being able to detect their presence?

Secure Undersea Communications—
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Heavy Military Electronics Dept.

GENERAL ELECTRIC
Court Street, Syracuse, New York

MIXER-PREAMP UNIT

New LEL Model MMX Mixer-Pre-amplifier integrates the microwave mixer with the IF preamplifier. Each



MMX unit is tested at X band for gain and selectivity and adjusted for minimum noise figure. Standard output frequencies are 30 and 60 mc. Other assemblies for C, S, KA and KU bands with pre-selector and local osc available if desired.—LEL, Inc., 280 Oak St., Copiague, N. Y.

For more information circle 154 on inquiry card.

WAVEGUIDE TERMINATION

Small in size, but with 200 watt capacity and using no fins or forced-air cooling, this 7-10 kmc waveguide



termination employs RADAMIC, a plastic absorbing material dimensionally stable to 2000°F. Maximum VSWR is 1: 1.1.—Radar Design Corp., Pickard Drive, Syracuse 11, N. Y.

For more information circle 155 on inquiry card.

GLASS-CERAMIC RADOMES

Pyroceram radomes, formed from molten glass then heat-treated to convert to a high-strength, high temperature glass-ceramic material are here

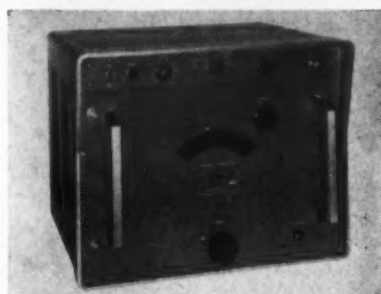


shown under production for Navy's Tartar Missile. Information on Pyroceram characteristics is available on request.—Corning Glass Works, Corning, N. Y.

For more information circle 156 on inquiry card.

MICROWAVE SIGNAL GENERATOR

Model KSS uses four plug-in microwave tuning units to cover 1,050 to 11,000 mc range. Supplies 80 to 400 milliwatts output in lower frequency range to 14-40 milliwatts in highest

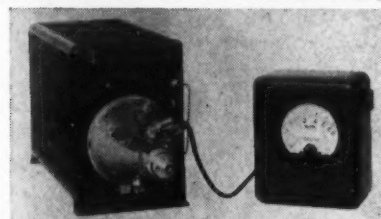


range for all microwave systems testing. Generates square-wave signals 10 to 10,000 pps, and cw signals internally, or may be externally modulated with minimum pulse rise and decay times of 0.15 μ sec.—Polarad Electronics Corp., 43-20 34th St., Long Island City 1, N. Y.

For more information circle 157 on inquiry card.

RF LOAD WATTMETERS

New Series 67 Termaline Load Wattmeters measure RF power up to 2500 watts, connecting directly to 50-ohm coaxial line as accurate termination in the 30 to 500 mc range.

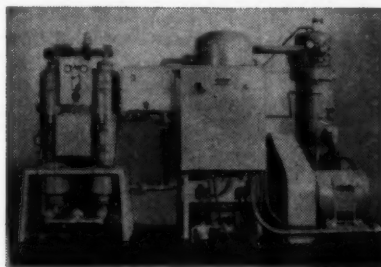


Each unit consists of load resistor-voltmeter unit and indicating meter calibrated in watts. No external power needed.—Bird Electronic Corp., 1800 East 38th St., Cleveland 14, Ohio.

For more information circle 158 on inquiry card.

DRY-AIR SYSTEMS

Dry-air pressurization systems for instrument-air, transmission line purging, and control-air applications



in military applications feature the Heat-Less Dryer, permitting dew-points as low as -180°F , complete oil rejection, and entirely unattended operation.—Trinity Equipment Corp., Cortland, N. Y.

For more information circle 159 on inquiry card.

New Miniaturization Techniques for Inertial Elements

Demands for a short-time inertial gyro for use in the Army's Sergeant Missile and other applications resulted in the development by the Aeronautical Div. of the Minneapolis-Honeywell Co., of the miniature integrating gyro or MIG design (Fig. 1) from the famous hermetic integrating gyro (HIG) based on the work of Dr. C. S. Draper of the Massachusetts Institute of Technology.

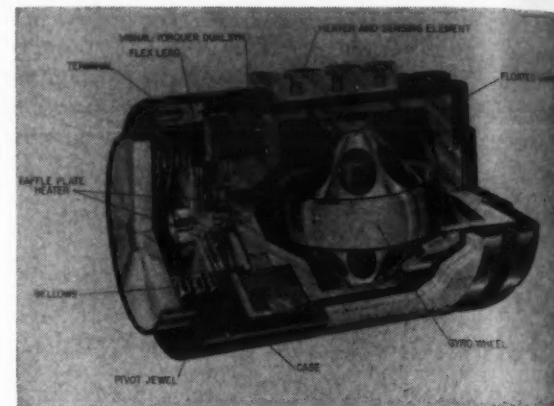


FIG. 1. MINIATURE INTEGRATING GYRO (MIG) cutaway shows combination signal and torque generating microsins termed the Dualsyn by Honeywell, one of several new design features of MIG.

The 30-ft Sergeant is a surface-to-surface missile capable of carrying an atomic warhead, and destined to replace the Corporal missile in the Army's tactical support arsenal. The Sergeant's guidance system, by utilizing the accuracy of the MIG gyros, will enable the warhead to be delivered on a target far beyond enemy lines without any danger of interception or jamming by any known means of enemy countermeasures. The Sergeant is also noted for its high mobility. It can be transported by air and launched under all weather conditions by a small crew.

In the interest of increasing accuracy while gaining the advantages of miniaturization, minimization of drift rate became a matter of major concern. While the most obvious method of cutting drift rate is to increase the angular momentum of the gyro wheel, Honeywell's Aeronautical Division engineers at Minneapolis, Minn. decided to attack the problem by decreasing gyro "uncertainties". Some of these major uncertainties are dimensional stability under temperature variation and shock; lower power consumption to reduce unwanted heating, electromagnetic nonlinearities and asymmetries, and vibration torques due to anisoelectric design. The engineers drew on seven years of experience in design and production of floated gyro experience to effect the improvements which resulted in the MIG.

MILITARY SYSTEMS DESIGN

The most obvious of these improvements are the combining of the signal and torque generators into a single dual-microsyn, designated the Dualsyn, and the natural consequence of placing the gimbal in one end of the case and Dualsyn in the other. Two ac windings for the signal generator and two dc windings for the torque make up the four windings of the Dualsyn.

Other design changes include (1) reduction of the gimbal suspension pivot to 0.016", (2) a new method of fluid fill that virtually eliminates balance-shifting air bubbles, (3) an isoelectric spinmotor and mounting structure to improve performance under vibration,

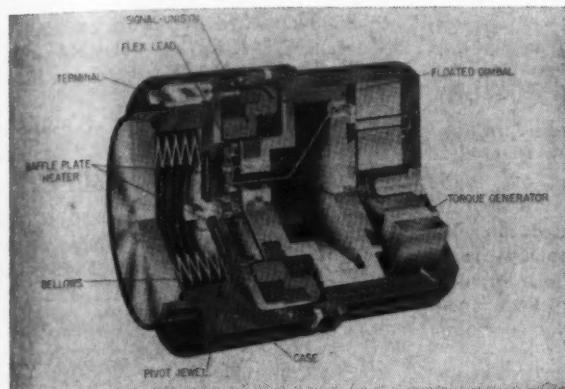


FIG. 2. MINIATURE PENDULOUS ACCELEROMETER (MPA) has many parts interchangeable with MIG. Rates of acceleration detected by MPA are fed back to null-seeking MPA in closed-loop system.

(4) an improved end bellows allowing flotation fluid changes over a wide range of internal temperature changes, and (5) flex leads to supply current to the gyro rotor which have an elastic restraint of only 0.04 dyne-cm per milliradian.

Characteristics of the MIG include drift of less than 0.5°/hr., which includes maximum drifts due to anisoelectricity in gimbal and motor structures of 0.02°/hr/G². Gimbal travel is held to ±3° of null, and operating temperature is approximately 180°F with the spinning motor consuming 2.5 watts maximum.

Miniature Pendulous Accelerometer

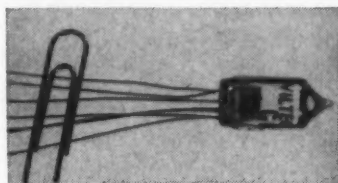
A companion element to the new MIG gyro is the Minneapolis-Honeywell new miniature pendulous accelerometer (MPA) developed for use in a central air data platform for a new manned interceptor. The MPA measures only 1.75" by 1.75" dia and weighs only 0.4 lb (Fig. 2).

The floated gimbal of the MPA contains the accelerometer's pendulous mass with a pendulosity of 1,000 dyne-cm. Rates of acceleration detected by the MPA are passed through signal generator and platform electronics and returned through a closed loop system to the null-seeking MPA through its torque generator. Threshold sensitivity is 10⁻¹⁴G.

For more information on MIG circle 160 on inquiry card.
For more information on MPA circle 161 on inquiry card.

TRIGGER TUBE

Type WC-18 cold-cathode trigger tube controls up to 1000 amperes peak current with input signal of a

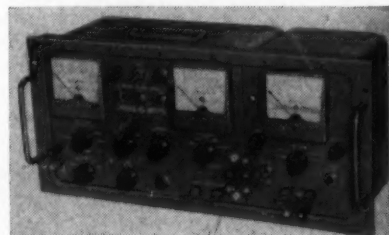


few microamperes, with anode delay of a few μsec and at altitudes to 65,000 ft.—Wiltec Electronics, Inc., 53 Water St., So. Norwalk, Conn.

For more information circle 162 on inquiry card.

MILLIMICROAMMETER

Model MA-259 millimicroammeter (shown on right) now extends range of Diode Tester Model DT-257 from 50μa down to 0.01μa to measure low reverse current characteristics of sili-

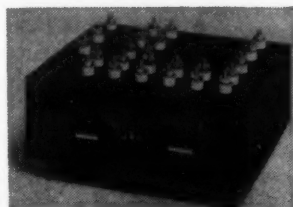


con diodes. New meter is self-contained and battery powered.—Teletronics Laboratory, Inc., 54 Kinkel St., Westbury, N. Y.

For more information circle 163 on inquiry card.

PRECISION RESISTANCE SET

Model BMR-105 ultra-stable ultra-precise resistance set for use in digital-to-analog conversion is accurate



to within 15 parts per million, includes oil bath to limit transient thermal effects to max 0.0005% of full scale.—Julie Research Labs., Inc., 556 West 168th St., New York 32, N. Y.

For more information circle 164 on inquiry card.

SILICON RECTIFIERS

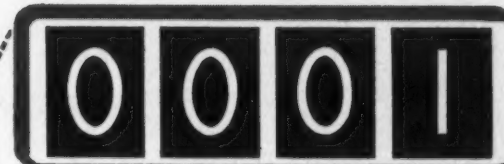
Diffused-junction silicon rectifiers in standard Top Hat and Stud Mounted welded packages feature very low back currents at high temperatures, high surge current capacity and excellent stability. Meet or exceed environment MIL-T-19500A specs.—Semiconductor Products Div., Motorola, Inc., 5005 E. McDowell Rd., Phoenix, Ariz.

For more information circle 165 on inquiry card.

The NEW Series BH100

MILLI-V-METER*

DIGITAL READOUT



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0.1%

THE INSTRUMENT with the TAPE-SLIDEWIRE

Highly accurate digital display of

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Every discrete scale unit is a calibrated point.

100 calibrated points per foot of slidewire length.

Slidewire up to 12 feet long.

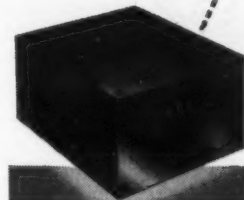
LINEAR, PARABOLIC, LOGARITHMIC
FUNCTIONS DISPLAYED IN DIRECT DIGITAL RELATION...COMPOUND RANGES,
PLUS & MINUS SCALES FROM ZERO,
SUPPRESSED RANGES

Full information is available for the asking:

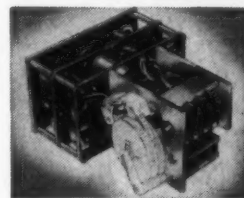
**B & H INSTRUMENT
CO., INC.**

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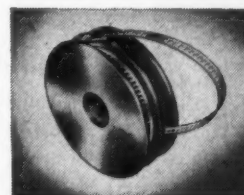
Sales-Engineering Offices: COMPTON, CAL., VALLEY STREAM, L. I., N. Y. DAYTON, OHIO, TORONTO, ONT. (George Kelk Ltd.), MITCHAM, SURREY, ENGLAND (Bryans Aeroequipment Ltd.)
For more information circle 56 on inquiry card.



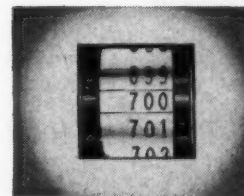
SMALL SIZE — This compact, transistorized, servo-driven instrument measures only 3 x 5 x 5 1/4".



ALL INCLUSIVE — With Zener reference, power supply, amplifier, servo motor, 144" tape-slidewire.



TAPE-SLIDEWIRE — Mounted on side-by-side spools, slidewire is embedded in edge of tape, punched for sprocket drive.



PRINTED READOUT — Calibration printed on tape available to measure steady-state conditions or where input deviates more than 13%.

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For more information circle 57 on inquiry card.

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5 mc Data Bloc • Data-Pac

. . . Data Bloc units are basic building blocks which can be reused any number of times . . . compact design permits rapid assembly of shift registers, counters, pulse generators for digital logic and data handling systems . . . later production runs made easy by compatible Data-Pac units . . .

NMR instrumentation, electromagnets and power supplies, error signal comparator . . . digital components.



HARVEY-WELLS ELECTRONICS, INC.

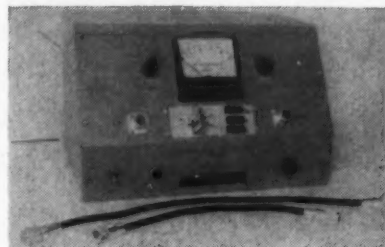
Research and Development Division

5168 WASHINGTON ST., W. ROXBURY 32, MASS.

For more information circle 58 on inquiry card.

DIODE PULSE TESTER

New Model ND-1 (JAN-265) Standard Diode Pulse Recovery Test Set, for use with suitable square-wave generator and oscilloscope, operates over ranges of: Forward bias cur-

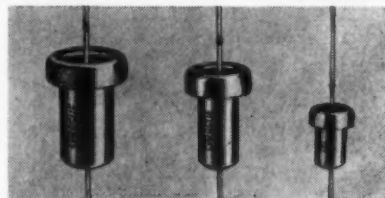


rent, 2 to 40 ma; inverse voltage 5 to 50v; load resistance, 500 to 3000 ohms; measurement time interval 0.1 to 10 μ sec.—*The Indikon Company, Inc., 76 Coolidge Hill Rd., Watertown 72, Mass.*

For more information circle 166 on inquiry card.

TANTALUM CAPACITORS

Improved cup style Tantalex capacitors, not subject to fluctuation in capacity or early failure due to



short circuit, also have non-tarnishing external finish. New characteristics bulletin 3710A on request.—*Sprague Electric Co., 43 Marshall St., North Adams, Mass.*

For more information circle 167 on inquiry card.

MINIATURE CAPACITORS

New 50-volt hermetically sealed Type AQF subminiature capacitor made to MIL-C-25A operates over

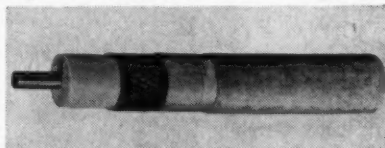


—65° to 125°C range with less than $\pm 3\%$ variation. Ratings from 0.027 mfd to 2.0 mfd.—*Astron Corp., 255 Grand Ave., East Newark, N. J.*

For more information circle 168 on inquiry card.

HIGH-POWER RF CABLE

Type RG-11U cable insulated with extruded Teflon and external wrapping of Teflon-insulated tape and

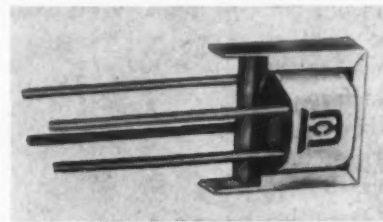


fiberglass is designed for high-power, high-temperature RF applications. Technical data on request.—*Times Wire and Cable Co., Inc., Wallingford, Conn.*

For more information circle 169 on inquiry card.

TRANSISTOR TRANSFORMER

New Veri-Miniature Transistor Transformers, with impedance ranges

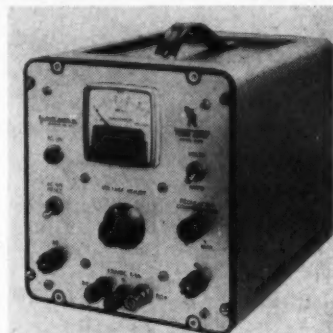


to match new transistors, are available in molded open frame or plug-in tab mounted construction. 24-page catalog on request.—*Microtran Co., Inc., 145 E. Mineola Ave., Valley Stream, N. Y.*

For more information circle 170 on inquiry card.

SEMICONDUCTORIZED POWER

New power supply uses unique semiconductor properties in new circuit concepts to: (1) cut off load power and reduce input within 30 μ sec upon external short circuit; (2) transfer excess heat dissipation from power transistors to external convectors; and (3) protect regulator system against excess input voltage



transients. Model 105TA provides from 1 to 100 v dc continuously variable at 0 to 0.5 ampere, Model 1010T provides same output voltage at twice the current capacity. Both models accept input voltage from 105-125 v, 55-440 cps, provide regulation to 15 millivolts or 0.05% (whichever is greater), with less than 1 mv ripple.—*Power Designs, Inc., 89-25 130th St., Richmond Hill 18, N. Y.*

For more information circle 171 on inquiry card.

MINIATURE FEED-THRU

New feed-thru insulator, No. CF-408-X87, uses Teflon body which compresses for press-fit mounting.

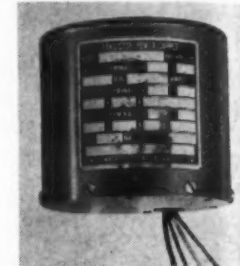


Hole lengthwise in terminal allows rapid soldering. Withstands high-voltage, high frequency and high temperature.—*Fluorocarbon Products Inc., Div. of U. S. Gasket Co., Camden 1, N. J.*

For more information circle 172 on inquiry card.

SQUARE WAVE POWER

Model 591AC transistorized power supply delivers 50 VA output power at 115 v 400 cps, square-wave, from

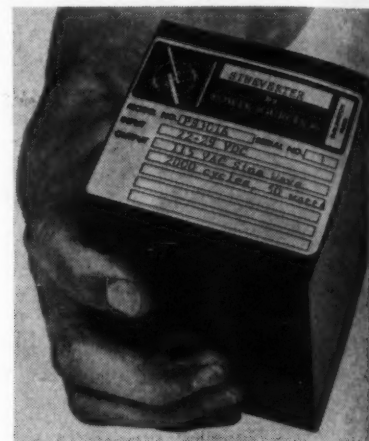


a 28 v dc line. Other outputs from 6 to 1200 vrms and frequencies from 400 to 2000 cps are available on request. Meets MIL-E-5272B.—*Arnold Magnetics Corp., 4613 W. Jefferson Blvd., Los Angeles 16, Calif.*

For more information circle 173 on inquiry card.

2000 CPS POWER SUPPLY

New Sineverter Model SV2C1200 supplies 50 watts clean sinewave 115 v 2000 cps power from 22-29 v dc with transients per MIL-E-5894A.

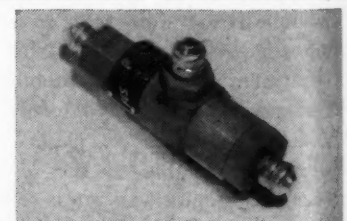


Meets rigid military environmental specs for missile use, cannot be damaged by overload, shorts, or open circuit operation.—*Power Sources, Inc., Burlington, Mass.*

For more information circle 174 on inquiry card.

GAGE SAVER

New Series FLP valve, designed for protection of ultra-sensitive low pressure wind tunnel and environmental chamber instrumentation, uses



reference pressure port for protection down to —10 psig. Available from stock in 11 combinations of pressure connections.—*Fisher Controls Inc., 1928 Lincoln Blvd., Santa Monica, Calif.*

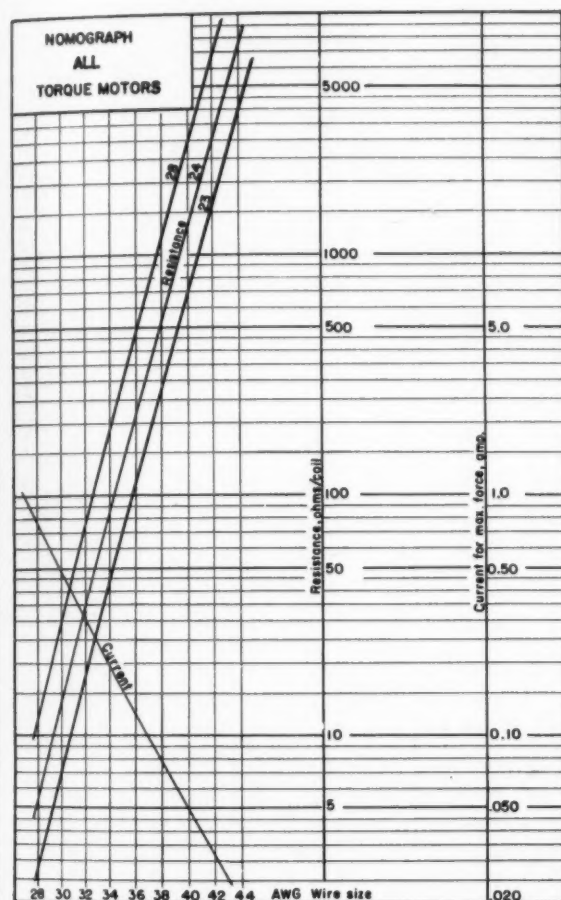
For more information circle 175 on inquiry card.

MILITARY SYSTEMS DESIGN

Nomograph for Torque Motor Applications

The nomograph shown below is designed to allow a design engineer to compute the current required for a given torque motor application, or conversely to determine the coil resistance needed for maximum force from any given model torque motor if the current is known.

The resistance lines on the nomograph are lines of constant power (the power required for maximum force from the torque motor is constant, independent of the current required), for each model of torque motor.



To find the current required to drive a Model 24 Torque Motor with 500 ohm coils, follow the vertical scale labeled "Resistance, Ohms/coil" to 500 ohms. Follow the 500 ohm line left to its intersection with the Model 24 resistance line. The wire size indicated at this junction is #38AWG. Follow down the vertical #38 line to its intersection with the "Current" line. Follow the horizontal line at this intersection right to the current scale to determine the current for maximum force; in this case, 0.08 ampere or 80 ma.

By reversing the procedure, the nomograph may be used in determining the coil resistance for any given model torque motor. (Nomograph from 6-page Torque Motors brochure, Raymond Atchley, Inc., 2340 Sawtelle Blvd., Los Angeles 64, Calif.)

For this literature circle 176 on inquiry card.

ROTARY ACCELERATOR

Model T-16-A test accelerator for pit installation has acceleration range to 100 G. Limiting size is an object 60" cube, and weights up to 500 lbs

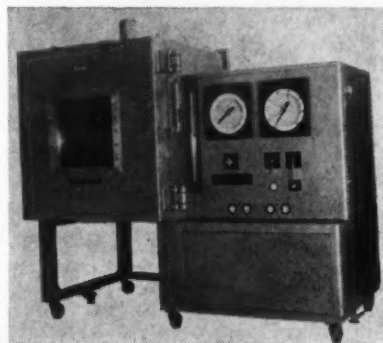


at each end of rotating arm can be tested at 100 G. 50 slip rings provide electrical connections to rotating transducers and stationary instruments. 30 hp dc drive motor and associated motor-generator provide power from 220 to 440v, 60 cps source.—Schaevitz Machine Works, Pennsauken, N. J.

For more information circle 177 on inquiry card.

ALTITUDE/VIBRATOR CHAMBER

New Chemosphere test chamber for altitude testing in the 100,000 to 260,-

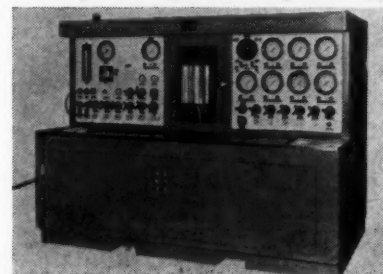


000 ft range, temperature testing in the -100° to 300°F range, with vibration table inside the chamber to eliminate push rods and linkages.—Conrad, Inc., Conrad Square, Holland, Mich.

For more information circle 178 on inquiry card.

HYDRAULIC COMPONENTS TEST

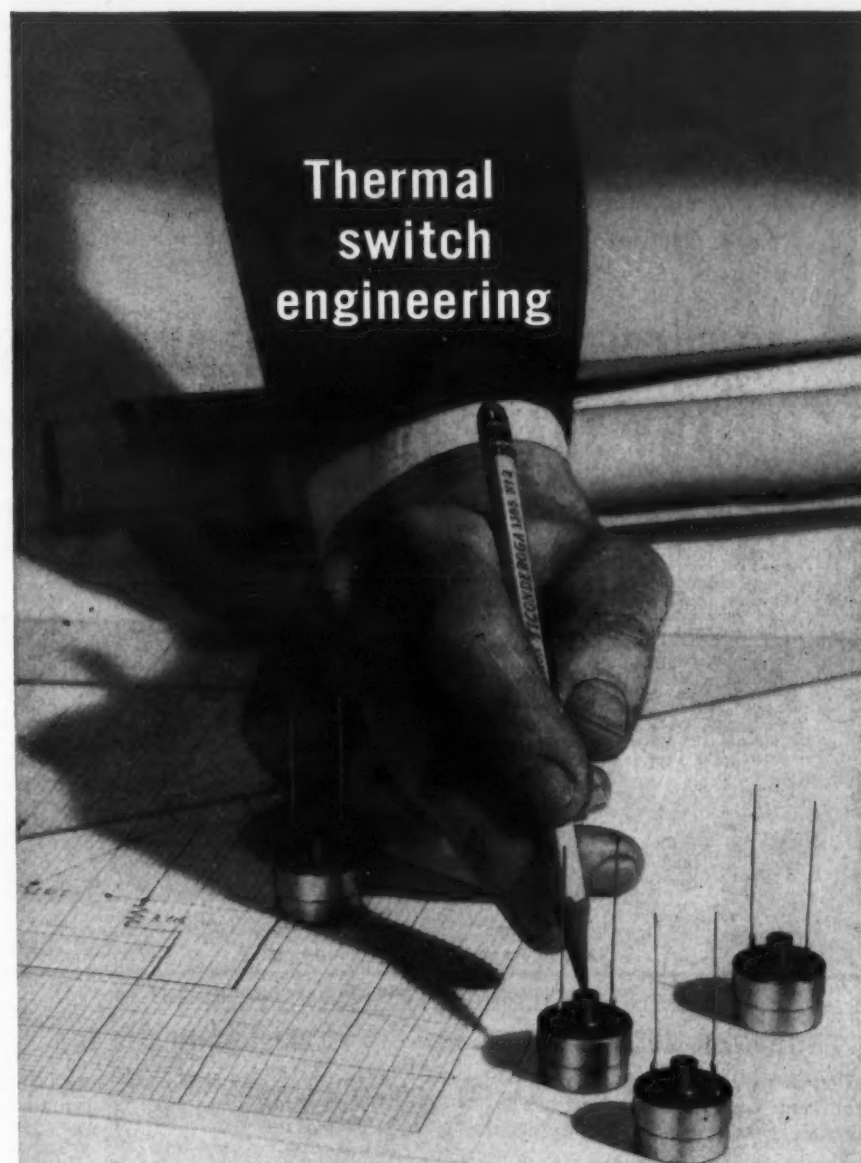
Test Console, Model 9500, for static and dynamic testing of hydraulic missile components provides up to 20 gpm



at 3000 psi or 9.7 gpm at 5000 psi, and from ambient to 350°F, ±2°F. Test fluid is filtered down to 2-5 microns. 20,000 psi is available for static testing.—Geo. L. Nankervis Co., 15400 Fullerton, Detroit 27, Mich.

For more information circle 179 on inquiry card.

Thermal switch engineering

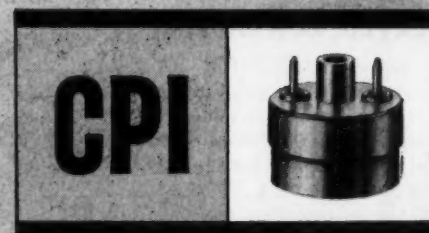


ANOTHER "CRITICAL" CONTROL SWITCH FROM CPI RESEARCH

If you are concerned with measurement of surface temperatures in aircraft and airborne electronic equipment in confined spaces, this may be a thermal switch you could use. We designed and manufactured it to meet exacting specifications of a prominent aircraft manufacturer.

Chances are your needs may require modifications or even a completely new switch. We have always realized that there are few "critical" control switches that can be all things to all people. That's why we have the research and development engineers who can and do tackle specific problems of thermal control. Can we help you solve yours?

This new hermetically sealed, bi-metal, single or 2-wire switch has calibration range of -20F to 600F; safe momentary overshoot to 800F; available with various type mountings. When inquiring, mention "button" switch.



CPI

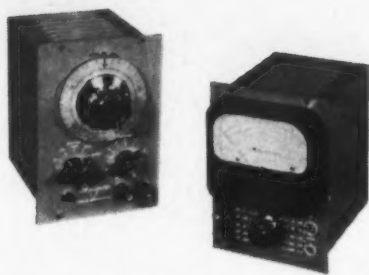
CONTROL PRODUCTS, INC.

311 Sussex Street, Harrison, N. J.

For more information circle 59 on inquiry card.

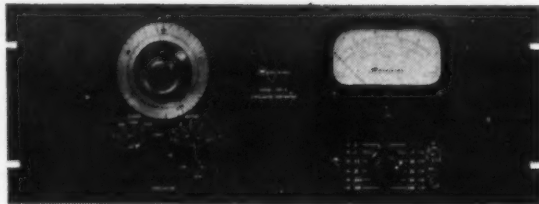
Precision in miniature

Waveforms Portable
520A Voltmeter
510B Oscillator



NOW! COMPACT RACK & PANEL MOUNTINGS IN ANY SHAPE OR FORM YOU NEED!

Waveforms precision voltmeters and oscillators give you top performance and uniform quality. Save space, too. So compact they mount on a 5" x 7" panel, these instruments are now available in any shape, form or mounting—rack or panel—you require. Waveforms integrated operation permits fast deliveries and low cost, even on custom specifications. Mass production techniques applied to special order work.



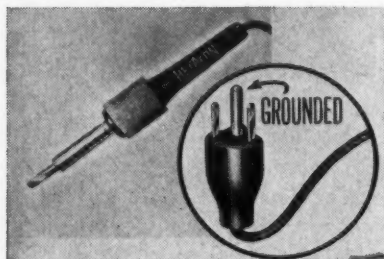
Send today for complete technical information.

Waveforms INC.
"Precision in miniature" ELECTRONIC INSTRUMENTS
343 Sixth Avenue, New York 14, N. Y. • WATKINS 9-2795

For more information circle 60 on inquiry card.

GROUNDING SOLDER IRON

Pencil soldering irons with 2-wire grounded connections now available for safety to operator and transistor



circuits, in sizes from 12 to 60 watts.
—Hexacon Electric Co., 295 West Clay Ave., Roselle Park, N. J.
For more information circle 180 on inquiry card.

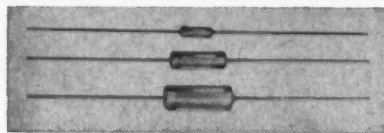
ISOLATED POWER SUPPLY

New power supply for resistance type transducers uses unique feedback system to provide isolation from line frequencies and noise previously obtained only from batteries. Fully transistorized unit 7" x 9" x 14" mounts three supplies per standard rack, provides 0-20 volts at 1 ampere with integral voltmeter and ammeter on each unit.—Moeller Instrument Co., 132nd St., & 89th Ave., Richmond Hill 18, New York City.

For more information circle 181 on inquiry card.

PRECISION RESISTORS

Pyro-Seal MIL Series resistors withstand shock to 500 G, tempera-



ture at 200°C, acceleration at 100G and vibration over 15 G, far in excess of military specifications. Rated at 1/8, 1/4 and 1/2 watt.—Pyrofilm Resistor Co., Inc., U. S. Highway 46, Parsippany, N. J.

For more information circle 182 on inquiry card.

VERY LOW-G SWITCH

Model 60U-01 unidirectional Inertia Switch for missile and airborne applications closes normally-open contacts

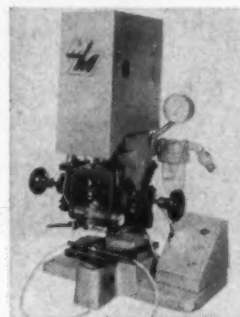


within 35 milliseconds when accelerated beyond factory preset (or user-adjustable) G values in the 0.05 to 1.0 G range.—Inertia Switch, Inc., 311 West 43rd St., New York 36, N. Y.

For more information circle 183 on inquiry card.

TUBING MARKING MACHINE

PVC and other types of spaghetti tubing are economically marked in small quantities on Model 1002 machine. Imprints up to 22 characters

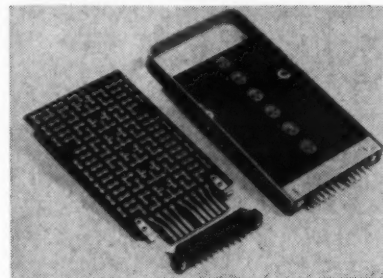


wide are quickly changed by rotating type wheel. Heated type and ink make permanent imprints.—Markem Machine Co., Keene 75, N. H.

For more information circle 184 on inquiry card.

PLUG-IN CIRCUIT UNIT

Blank printed circuit cards for laboratory and developmental use in assembling neat transistorized circuits



are used with blank tube plug-ins, rack mounting trays, power supplies, etc., to provide complete systems.—Plug-in Instruments, Inc., 1416 Lebanon Rd., Nashville, Tenn.

For more information circle 185 on inquiry card.

SPRING ISOLATION MOUNT

New Type LR spring isolation mounting designed to reduce vibration and noise transmission combines steel springs for strength with noise-

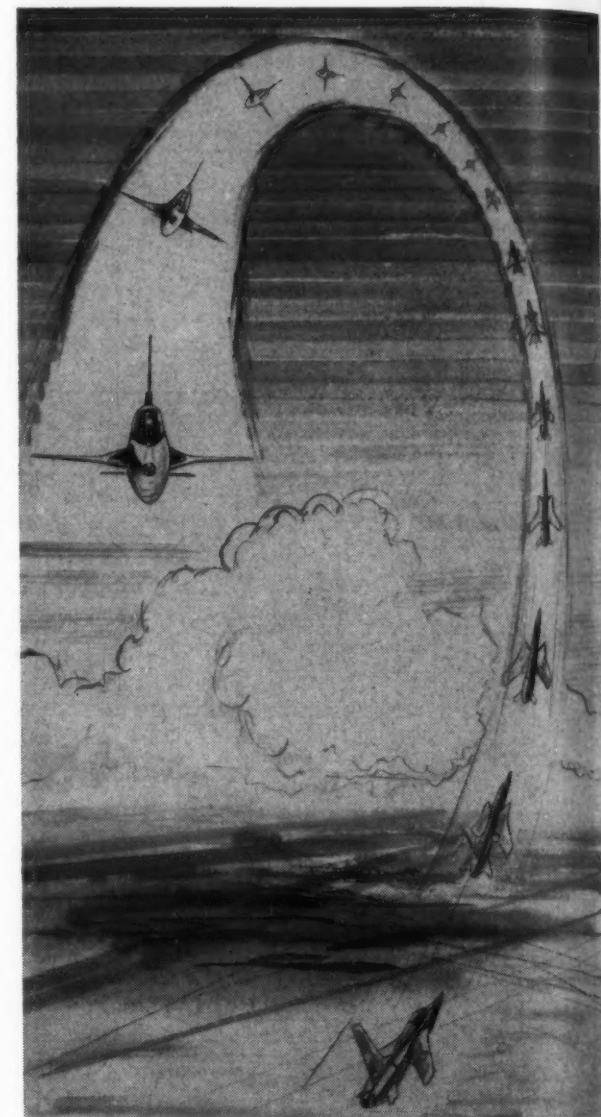


quenching rubber housing. Load capacity 150 to 1400 lbs/isolator. Effective in protecting instruments and precision equipment from vibration, noise and shock.—The Korfund Co. Inc., Long Island City, N. Y.

For more information circle 186 on inquiry card.

Flight Control System Flies Immelmann

The famous Immelmann maneuver, first used in World War I by the German Ace Max Immelmann to elude his pursuers and later adapted to toss bombing tactics has now been performed under automatic control by a Republic Aviation's F-105 using an FC5 Flight Control System manufactured by the Armament



and Control Section, Light Military Electronics Dept., General Electric Co., at Johnson City, N. Y. When executing this maneuver the aircraft completes the first half of a loop then rolls over to an upright position, thus changing direction by 180° with a simultaneous gain in altitude (Fig. 1).

The FC5 Flight Control System employs one pull-up rate gyro and a roll-out rate gyro, each with one degree of freedom, and one vertical rate gyro with two degrees of freedom. The vertical gyro tells the system when to start and stop a maneuver; for example, it tells the system when the aircraft is on its back during the looping stage. This ability of the vertical gyro to retain control in both pitch and roll

MILITARY SYSTEMS DESIGN

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without tumbling is the heart of the system. The Flight System also provides three-axis stability augmentation, slideslip control, pilot relief modes of operation, and automatic instrument landing. Pilot relief modes include pitch attitude, roll attitude, heading, altitude and Mach control.

The FC5 System uses one high performance series, limited travel, hydraulic actuator for control of each aircraft surface (three surfaces are controlled) plus two parallel actuators for the automatic modes of operation. The system amplifier also uses magnetic amplifiers, transistors, and rugged subminiature electronic tubes to achieve the optimum combination of lightweight, flexibility and reliability, according to the company.

For more information circle 187 on inquiry card.

Using the Controlled Rectifier

Behaving similar to a gas thyration, the C-35 SCR (Silicon Controlled Rectifier) is a starting point for new applications besides the time-tested ones in which thyratrons, mercury-arc tubes, magnetic amplifiers, and power transistors are now being used. However, different design considerations and limitations apply to the C-35, formerly designated the ZJ39A.

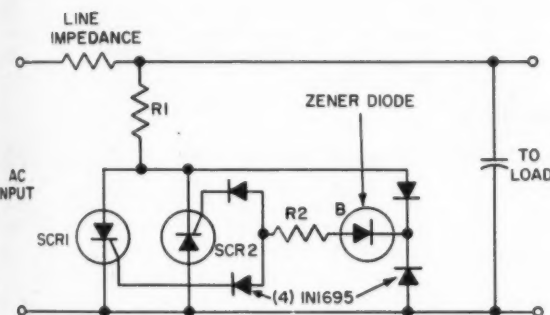


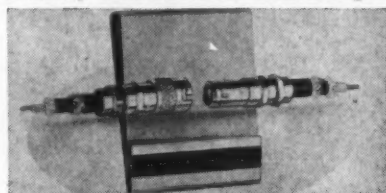
FIG. 1. SURGE VOLTAGE Suppressor.

Surge Voltage Suppression—The circuit shown in Fig. 1 can be extremely useful in protecting transistor and semiconductor rectifier circuits from harmful line surges. When the line voltage exceeds a predetermined value, one of the SCR's will fire, drawing enough line current to drop the voltage across line impedance. For the G35, the value of resistor R-1 should be selected to limit peak anode current during SCR switching to 100 amperes. The voltage level at which suppression starts is determined by the avalanche voltage of the zener diode. The slight delay until the SCR switches into full conduction may allow a voltage surge with extremely fast rate-of-rise to overshoot the allowable voltage before current conduction starts. This rate-of-rise may be reduced by a capacitor connected across the line. The circuit will of course recover its blocking ability at the end of each half cycle. (From new 76-page "Notes on the Application of the Silicon Unijunction Transistor," Semiconductor Products Dept., General Electric Co., Syracuse, N. Y.)

For this literature circle 188 on inquiry card.

TRI-AXIAL CABLE CONNECTOR

Miniature tri-axial connectors, said to be smallest, provide two concentric shields, accommodate cables up to

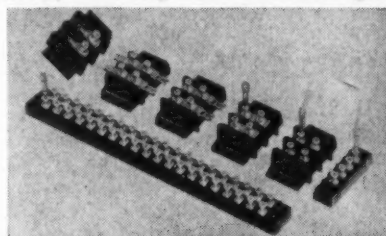


0.212" O.D. and have 500v rated capacity in overall dimension of 1"x3/4" dia.—Dage Electric Co., Inc., 67 N. Second St., Beech Grove, Ind.

For more information circle 189 on inquiry card.

TAPER PIN CONNECTOR BLOCKS

New miniature connector terminal blocks, meeting MIL-M-14E specs,



are available in number of combinations. Details on request.—Excellex Electronics, Inc., 335 Van Siclen Ave., Brooklyn 7, N. Y.

For more information circle 190 on inquiry card.

RE-ENTRANCY CONNECTOR

New REMI miniature connector contact employs metallic sleeves with long cantilever springs for easy in-

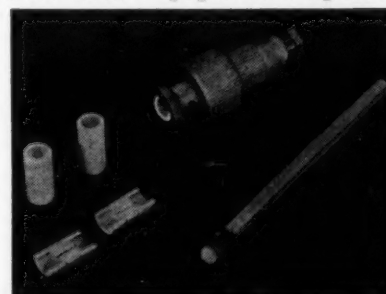


sertion, withdrawal, and operational stability. Full specifications on request.—U. S. Components, Inc., 454 East 148th St., New York 55, N. Y.

For more information circle 191 on inquiry card.

TEFLON MACHINING

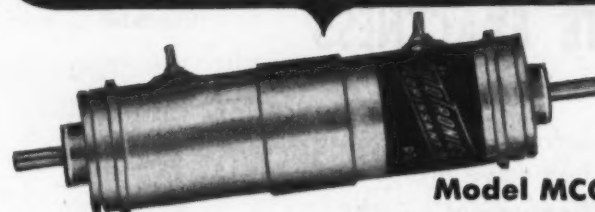
TFE "Teflon" stock is machined to 0.001" tolerance in double-cup shapes for Atlas ICBM connector on automatic screw equipment adapted to



TFE characteristics by Tri-Point. Information on Teflon Machining is available on request.—Tri-Point Plastics, Inc., Albertson, N. Y.

For more information circle 192 on inquiry card.

AUTOTRONICS for precision control



Model MCC

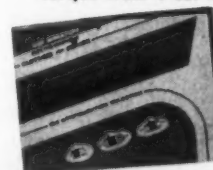
DUPLEX MINIATURE ELECTRO-MAGNETIC CLUTCH

DE-ENERGIZED—both flanges as well as the output shaft are free running.

ENERGIZED—either coil engages its respective flange to the output shaft.

The function of the shafts may be reversed so that a single input can be connected to either of two output shafts.

The model MCC is available in four sizes and two standard shaft configurations, pilot diameters from .500" to 1.250", torque from 4 oz. in. to 56 oz. in.



Write for catalog 957

for data on all Autotronics standard clutch and brake units.

AUTOTRONICS INC. Box 812, Rt. 1, FLORISSANT, MISSOURI

For more information circle 61 on inquiry card.

Introducing A LOW-PRICED SCOPE DOLLY

- ★ Sturdy steel, gray baked-enamel finish, meets military specifications
- ★ 5" ball-bearing rubber tired casters
- ★ Rubber gasket protects scope
- ★ 3 power outlets; 1 input
- ★ Storage area for pre-amplifiers
- ★ Storage shelf for tools, cord, etc.



Accommodates any standard scope by easy bracket relocations. From 6" to 12 3/4" wide; from 16 1/2" to 22 1/2" long.

\$59⁹⁵
F.O.B., Phila.

Shipped knocked down (45 lbs.), assembled in minutes. Special modifications to suit your requirements. Quantity prices on request.

Choice territories available for sales representation. Write for information.

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For more information circle 62 on inquiry card.

Precision instruments require mirrors and optical parts of

ABSOLUTE EXACTNESS

OUR

- first surface mirrors with half-wave protection
- semi-transparent mirrors metallic and non-metallic
- beam splitters
- optical filters

Guaranteed to be

Without

DISTORTION DIFFRACTION DIFFUSION

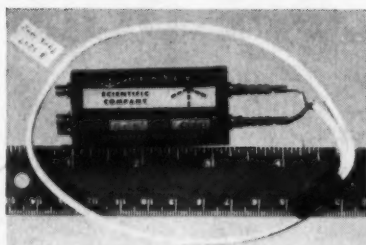
All work to closest specification by the pioneers and leaders for a quarter of a century in depositing metal films. Send for our free booklet.

EVAPORATED METAL FILMS CORP.
Ithaca, New York
Dept. M

For more information circle 63 on inquiry card.

DISTANCE DETECTOR

This Distance Detector is a precision electro-mechanical transducer which generates a dc voltage as a function of distance. It is an all transistor design to provide reliability, long life, and low energy consumption.



A very high sensitivity gradient and fast response make it a particularly precise and versatile unit for a vast variety of micro-distance measuring jobs.

OPERATION: This device senses distance to a conductive surface because of the variation of coupling coefficient as a function of distance from the face of a special coil to the conductive surface.

SENSITIVITY: 1000 volts per inch with H-1 sensing head
400 volts per inch with H-2 sensing head
200 volts per inch with H-3 sensing head

RANGE: 10, 25 and 50 thousandths of an inch, with head types 1, 2, and 3 respectively.

RESPONSE: Flat from dc to a single lag at 50,000 cps.

SUPPLY: 12 vdc at 2ma

SIZE & MASS: 1.2" diameter x 2.5" long, 80 grams

COST: Model 15, \$72.00 with H-2 head. Additional standard heads \$6.00 each.

USES: Typical uses are control of location and indication and measurement of dimension, displacement, deflection, velocity, vibration, contour, creep, and counting.



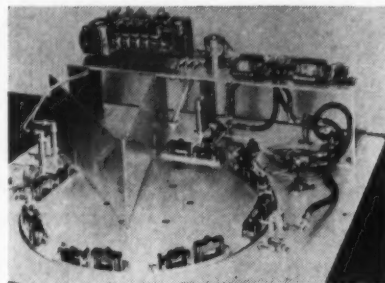
High speed proximity relaying attachments also available.

2811 Seventh Street
Berkeley 10, California
Phone: Thornwall 3-6306

For more information circle 64 on inquiry card.

SPRAY CLEANER

High-velocity, spray cleaner directs atomized Cobehn solvent against all areas of parts mounted on rotary turntable to achieve chemical cleanli-

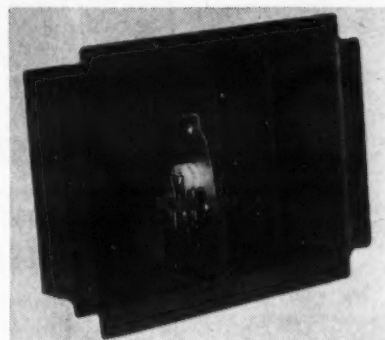


ness without residue or film. Integral ventilation removes all vapors.—Cobehn, Inc., Caldwell, N. J.

For more information circle 193 on inquiry card.

CERAMIC TUBE SOCKET

New UHF socket for G. E. #7077 ceramic microminiature tube is particularly useful in lumped-constant circuits, isolating input from output



by clamping grid directly to chassis barrier. Other contacts are silver-plated beryllium copper, supported in high-strength low-loss plastic.—Jetron Products, Route 10 Hanover, N. J.

For more information circle 194 on inquiry card.

PRODUCTION SOLDERING UNIT

Model 3374 Soldering Unit provides selectable temperature from 500° to 750°F for heavy duty yet draws only 100 watts input. Automatic control

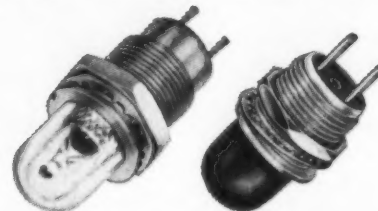


provides constant tip temperature for certified military soldering.—Eder Engineering Co., Inc. 1568 So. First St., Milwaukee 4, Wisc.

For more information circle 195 on inquiry card.

INDICATOR LIGHTS

Miniature indicator lights meeting MIL-L-6723 (ASG) accommodate AN3140 type incandescent lamps (Series L14,000) or NE2D neon

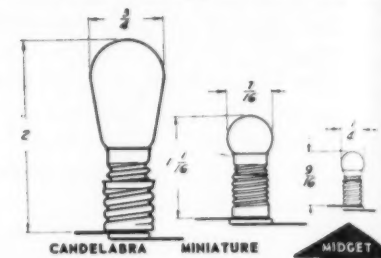


lamps (Series L15,000). Latter series has built-in resistor for 115 v operation. Data sheet L-5a on request.—Hetherington, Inc., Folcroft, Pa.

For more information circle 196 on inquiry card.

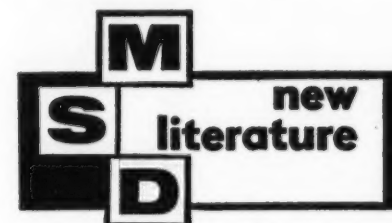
MIDGET SIZE LAMPHOLDERS

Superminiature lampholders to fit extra-small Tiny-lite bulbs are avail-



able in many bracket styles for miniaturized equipment. Data sheet on request.—Drake Mfg. Co., 1711 W. Hubbard St., Chicago 22, Ill.

For more information circle 197 on inquiry card.



RF-IF AMPLIFIERS for military applications, are described in 17-page catalog.—LEL, Inc., 380 Oak St., Copiague, L. I., N. Y.

Circle 198 on inquiry card.

DIGITAL TEST BUILDING BLOCKS are listed in new 4-page digital test equipment catalog.—Digital Equipment Corp., Maynard, Mass.

Circle 199 on inquiry card.

DIGITAL INSTRUMENTATION for counter-timers, frequency-period meters, time interval meters, described in 12-page catalog.—Computer Measurements Co., 5528 Vineland Ave., No. Hollywood, Calif.

Circle 200 on inquiry card.

MODULAR DIGITAL SYSTEMS and including shaft position encoders, read-out equipment, etc., are described in 4-page bulletin.—Datex Corp., 1307 South Myrtle Ave., Monrovia, Calif.

Circle 201 on inquiry card.

DIGITAL MAGNETIC 3C Random Access Memory is described in 6-page bulletin TCM.—Computer Control Co., Inc., 92 Broad St., Wellesley 57, Mass.

Circle 202 on inquiry card.

DIGITAL VOLTMETERS and accessories are described in new 4-page Bulletin 106-D.—Cubic Corp., 5575 Kearney Villa Rd., San Diego 11, Calif.

Circle 203 on inquiry card.

CARTESIAN TO POLAR coordinate converters, digital data transmission and X-Y recording equipment are described in series of 2-page catalog sheets.—Milgo Electronic Corp., 7601 N. W. 37th Ave., Miami 47, Fla.

Circle 204 on inquiry card.

MICROWAVE AND ELECTRONIC EQUIPMENT for Military & Commercial Systems are described in 1959 condensed 12-page catalog.—Sperry Microwave Electronics Co., Clearwater, Fla.

Circle 205 on inquiry card.

HIGH-SPEED DIGITAL PROCESSOR is described in new 6-page bulletin #3004.—Consolidated Electrodynamics, 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle 206 on inquiry card.

FREQUENCY METERS. Coaxial and Waveguide models covering 3.5 to 40,000 mcs ranges are described in 6-page bulletin 200. Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.

Circle 207 on inquiry card.

SEFAR, new end-fire directional underwater sound source is described in new data sheet.—Acoustica Associates, Inc., 26 Windsor Ave., Mineola, N. Y.

Circle 208 on inquiry card.

TELERECORDING BATHYTHERMOMETER Model 470 is described in 4-page Engineering Bulletins.—Hytech Corp., 257 Killgore St., Playa Del Rey, Calif.

Circle 209 on inquiry card.

UNDERWATER ACOUSTICS—new 16-page Sonar facilities Brochure describes current research, development and engineering projects in this field.—Electronics Div., Stromberg-Carlson, 1400 N. Goodman St., Rochester 3, N. Y.

Circle 210 on inquiry card.

MILITARY SYSTEMS DESIGN

Miniature Servo Motor-Brake Design

Reliability is the prime consideration in the production of Western Gear's one-inch servo motor brake combination. Some of the important factors in the achievement of reliability are design, manufacturing capabilities and quality control. These three factors are inter-related and must function as a team. A sound mechanical design requires that production processes, manufacturing techniques and tooling play an important role in the design considerations. The manufacturing capabilities employed by the Electro Products Div., Western Gear Corp. of Pasadena, Calif., include precision machinery, special tooling, environmental controlled assembly area, and many special machines jig and fixtures, especially developed to insure the design requirements being met.



Reliability of the servo motor with brake is further improved by encapsulation of the stator winding with a newly developed technique that allows the insulation of the stator to withstand a 1500 RMS high potential test between phases, as well as from either phase to ground.

This insures reliable performance over a long period of operation with an ambient temperature variation of minus 55°C to 125°C. Higher temperature requirements can be met, but must be engineered individually to specific applications for best results.

Characteristics of the servo motor brake combination include:

- 1) Stall Torque, motor along 0.48 oz-in;
- 2) size 1" dia x 1.85" long
- 3) designed to meet MIL-E-5272
- 4) operates from 115v 400 cps both phases
- 5) nominal impedance 1450 + j1600 ohms

The unit has a stainless housing, end bells and shaft, and can be produced with Size 10, Size 11, or one inch mounting. A design including an integrally mounted gear box with ratios up to 8000 to one is also available. This gear box adds approximately one inch to the overall length of the unit.

The addition of the brake does not change the linearity of the speed torque curve as the brake produces a constant torque regardless of the operating speed of the unit. The brake value is set during manufacture at a range of 0.03 to 0.1 oz-in with a setting tolerance of ± 0.01 oz-in.

For more information circle 211 on inquiry card.

INERTIAL GUIDANCE components, engineering reports are listed in new 8-page pocket brochure.—Sterling Precision Corp., 17 Matinecock Ave., Port Washington, N. Y.

Circle 212 on inquiry card.

LINEAR AND ROTARY ACTUATORS, 400 cps and dc, are listed in new 8-page Helco catalog of electro-mechanical equipment for Missiles and Aircraft.—Hoover Electric Co., Hangar 2, Port Columbus Airport, Columbus, Ohio.

Circle 213 on inquiry card.

PRECISION-MADE SERVO MOTORS—20-page specifications catalog No. 5000 fully describes all basic models.—John Oster Mfg. Co., Avionic Div., 1 Main St., Racine, Wis.

Circle 214 on inquiry card.

SERVO SYSTEM "Technical Information for Engineers," (fifth edition), includes transfer functions and db-Log ω plots, also engineering data on all company components, in new 48-page (8½"x11") handbook, free on request.—Kearfott Co., Inc., 1500 Main Ave., Clifton, N. J.

Circle 215 on inquiry card.

SYNCHRO DATA parameters of synchros and resolvers are given in 9" x 11" chart suitable for wall-mounting.—Theta Instrument Corp., 48 Pine St., E. Paterson, N. J.

Circle 216 on inquiry card.

ELECTRIC MISSILE SERVOS with characteristic performance curves are described in new 4-page brochure.—Lear, Grand Rapids Div., 110 Ionia Ave., N. W., Grand Rapids 2, Mich.

Circle 217 on inquiry card.

SERVOSCOPE MODEL H for analysis of servo systems is described in bulletin TDS-100.—Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, L. I., New York.

Circle 218 on inquiry card.

MISSILE AND SPACE VEHICLE research and development is described in new 23-page facilities brochure, "General Electric's Missile and Space Vehicle Department."—General Electric Co., Room 5C, 3198 Chestnut St., Philadelphia 4, Penna.

Circle 219 on inquiry card.

FLIGHT TESTS of X-15, First Manned Space Ship, are described in new issue of "Readout".—Ampex Corporation, Instrumentation Div., 934 Charter St., Redwood City, Calif.

Circle 220 on inquiry card.

SILICON GLASS DIODES in general purpose and fast switching types are listed in new 4-page catalog with characteristic curves.—Silicon Transistor Corp., Carle Place, L. I., N. Y.

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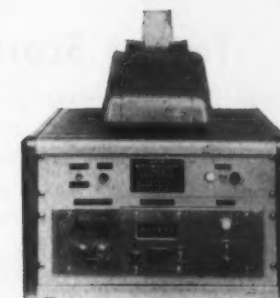
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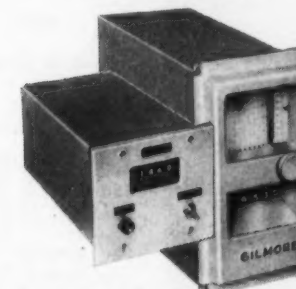
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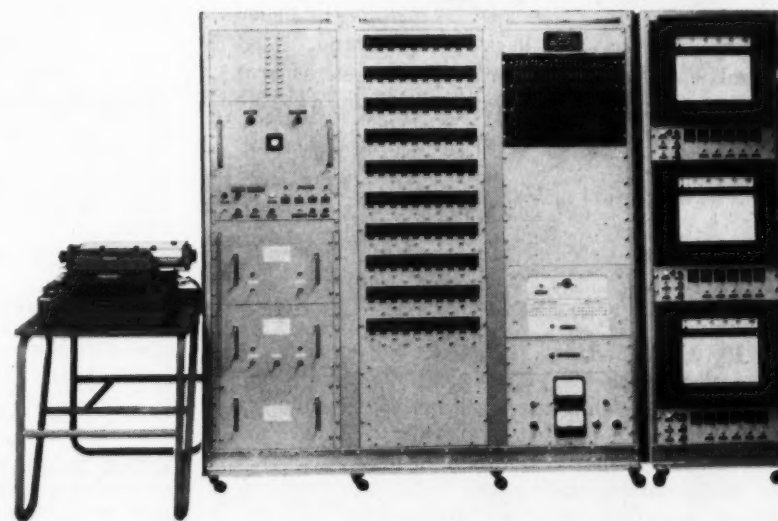
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Target Scoring Devices

Miss-Distance Measuring Systems designed by the Electronic Specialty Co., resulted from a study of the operational need of Scoring Evaluation Groups. The first design criteria was a system that would eliminate the need to modify the missile being appraised (by installing a cooperative device). The second was that of having a simple, stable, reliable system. The third was a capability of Course Indication to permit angle of attack recognition.

	MDI I	MDI III
Volume	500 cu in (max.)	650 cu in (max.)
Weight	13 lbs (max.)	16 lbs (max.)
Speed	Mach 0 to 10 (Relative closing speeds)	Mach 0 to 10 (Relative closing speeds)
Altitude	100,000 feet	100,000 feet
Acceleration	150 G for 2 seconds	150 G for 2 seconds
Shelf Life	2 years	2 years
Vibration	Per customer requirement	Per customer requirement
Detection	Go-No-Go Detection Circles	Minimum miss-distance measurement in feet
Accuracy	10% of range	2% of range
Course Indication	No	Yes
Intercept	Upon customer request	Upon customer request
Detonation Indication		
Telemetering Required	None	2 Channels

This unique system is less complex than most pulse or doppler radars, yet combines the best features of both. The system has the desired detection range without modifying intercept missiles, and will measure range with the requisite accuracy. Additional advantages are simplicity of design, high reliability, non-critical tuning, small size, light weight and low production cost. Complete MDI subsystems can be supplied to suit particular target vehicle environments. In many applications, the MDI transmitter can be used to telemeter the score back to the ground. Brief operational specifications of two typical systems are:

(From 40-page facilities catalog, Bulletin AV-100, —Electronic Specialty Co., 5121 San Fernando Rd., Los Angeles 39, Calif.)

For this literature circle 222 on inquiry card.

BOOK REVIEWS

NOISE IN ELECTRON DEVICES, by Louis D. Smullin and Hermann A. Haus, [c1959], The Technology Press Massachusetts Institute of Technology and John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 411 p., clothbound, \$12.00, 9 1/4". Stresses mathematical theory and includes traveling-wave tubes, semiconductors, and transistors.

APPARATUS AND METHODS OF OCEANOGRAPHY, Part I, Chemical, [c1959] Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 341 p. 5 1/2" x 8 1/2", \$5.75. Working text and reference for departments of oceanography and marine biology. Simpler and better-known methods are fully explained, with attention also directed to advanced methods. Appendix contains tables and subject index.

New Literature—CONT.

AVIONICS PRODUCTS including static time delays, standard time delays, missile fuzes and programmers, automatic checkout equipment and voltage and frequency sensors are described in 40-page facilities catalog, AN-100. —Avionics Division, Electronic Specialty Co., 5121 San Fernando Rd., Los Angeles 39, Calif.

Circle 223 on inquiry card.

ACCESSORY EQUIPMENT for Aviation Missile and Space-Craft industries is described in new 26-page catalog.—Lyndon Aircraft, Inc., 140-61 Clifford St., Newark 5, N. J.

Circle 224 on inquiry card.

MISSILE TESTING and space-travel training equipment is described in 20-page catalog.—Guardite Div., American-Marietta Company, Wheeling, Ill.

Circle 225 on inquiry card.

DIRECT WRITING RECORDER, military and scientific applications are described in new 16-page booklet.—Brush Instruments, 37th & Perkins, Cleveland 14, Ohio.

Circle 226 on inquiry card.

MISSILE EVENT RECORDER with capacity of 21 channels of simultaneous on-off information is described in new spec bulletin No. 320.—Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, Ohio.

Circle 227 on inquiry card.

EVENT RECORDER for 30-channel recording on 100 ft electro-sensitive paper rolls feature optional quick change to high chart speed to record faulty or erratic operations is described in 4-page brochure.—Larson Instrument Co., 24 Orchard St., Tarrytown, N. Y.

Circle 228 on inquiry card.

MAGNETIC TAPE UNIT to extend capabilities of RW-300 Digital Control Computer is described in new 12-page brochure.—Thompson-Ramo-Wooldridge Products Co., P. O. Box 90067 Airport Sta., Los Angeles 45, Calif.

Circle 229 on inquiry card.

THERMOCOUPLE SYSTEMS FOR ADVANCED aircraft gas turbine engines are described in 16-page bulletin.—General Electric Co., Section A-6073, Schenectady 5, N. Y.

Circle 230 on inquiry card.

WORD INDICATOR LIGHTS for fault or functions of missile ground support or airborne equipment are described in 16-page "Roto-Tellite" bulletin.—Master Specialties Co., 956 East 108th St., Los Angeles 59, Calif.

Circle 231 on inquiry card.

DIFFERENTIAL PRESSURE INDICATOR, Deltadyne, is described in 2-page Bulletin A-109.—Aircraft Porous Media, Inc., 30 Sea Cliff Ave., Glen Cove, N. Y.

Circle 232 on inquiry card.

X-Y RECORDERS and Autograf data reduction accessories are listed in new 2-page catalog sheet D-4.—F. L. Moseley Co., 409 No. Fair Oaks Ave., Pasadena, Calif.

Circle 233 on inquiry card.

FIRE DETECTION systems to complete pneumatic systems for missiles and aircraft are described in new 12-page brochure.—Aviation Div., Walter Kidde & Co., Belleville, N. J.

Circle 234 on inquiry card.

COMMUTATING SWITCH having 45 air operated contact pairs is described with specs, also sample inquiry specification is included in new 2-page bulletin No. 8.030.—Electric Regulator Corp., Norwalk, Conn.

Circle 235 on inquiry card.

ENCAPSULATED TRANSFORMERS, 400 cps Clipper Series for aircraft, servo and other miniature uses, are described in new catalog sheet.—Sterling Transformer Corp., 297 No. 7th St., Brooklyn 11, N. Y.

Circle 236 on inquiry card.

WIREWOUND PRECISION Series E resistors, 1/2 to 1 watt, with tolerances to 1/4% are described in new data sheet.—Precision, Inc., 4748 France Ave., N., Minneapolis, Minn.

Circle 237 on inquiry card.

MICA, CERAMIC and paper capacitors in the 1-to-20,000 μ f range are listed in new 6-page short-form catalog A-58.—Electro Motive Mfg. Co., Inc., Willimantic, Conn.

Circle 238 on inquiry card.

ELECTROLYTIC capacitors, Type BCD, for mounting on printed wiring boards are described in new product bulletin BCD.—Aerovox, New Bedford, Mass.

Circle 239 on inquiry card.

PROPELLANT ACTUATED DEVICES. Six types of powder-powered devices are illustrated and described in 4-page Form PAD-358.—Beckman & Whitley, Inc., 973 E. San Carlos Ave., San Carlos, Calif.

Circle 240 on inquiry card.

ATTENUATORS, FIXED COAXIAL-MODEL 50 are described in 6-page brochure.—Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.

Circle 241 on inquiry card.

LIQUID-HANDLING valves, special products and systems engineering facilities are described in new 12-page catalog.—Koehler Aircraft Products Co., 409 Leo St., Dayton, Ohio.

Circle 242 on inquiry card.

GASEOUS OXYGEN FACILITY, 4-page illustrated brochure tells the story of gaseous oxygen testing of air and spaceborne components and systems, explains unique calibration of high-capacity mass flow meters.—Whittaker Controls Div. of Telecomputing Corp., 915 No. Citrus Ave., Los Angeles 38, California

Circle 243 on inquiry card.

NOISE REDUCTION by use of Eckous-tic Panels is explained in new 4-page Brochure, "Achievement in Acoustics". —The Eckel Corp., 155 Fawcett St., Cambridge 38, Mass.

Circle 244 on inquiry card.

SHOCK, NOISE AND VIBRATION CONTROL SYSTEMS are described in 12-page bulletin No. 714.—Lord Manufacturing Co., Erie, Pa.

Circle 245 on inquiry card.

AUTO-TRACER LATHE, Model 30 is described in an eight-page brochure.—Jones & Lamson Machine Co., Springfield, Vt.

Circle 246 on inquiry card.

CUSTOM RESEARCH, development and product design services are described in 12-page brochure, "Creative Engineering".—Westgate Laboratory, Inc., Yellow Springs, Ohio.

Circle 247 on inquiry card.

VACUUM TUBE ANODES of copper-cored Aliron are described in 9-page data bulletin IND-19.—Metals & Controls Corp., Attleboro, Mass.

Circle 248 on inquiry card.

GLASS REINFORCED Alkyd Molding Compounds in continuous rope form for electrical insulating bodies are described in new 4-page brochure, "Glaskyd".—Glaskyd, Inc., Perrysburg, Ohio.

Circle 249 on inquiry card.

TWENTYFOUR CARAT Acid Bright Gold-plating complex, Orosene 999, is described in new 4-page brochure.—Technic, Inc., P. O. Box 965, Providence, R. I.

Circle 250 on inquiry card.

FLEXIBLE MINIATURE COUPLINGS and shaft joints are listed in new 4-page data bulletin.—Fourdee, Inc., P. O. Box 6006, Orlando, Fla.

Circle 251 on inquiry card.

SELF-SEALING FASTENERS and seals are listed with MIL-Specs in new 12-page catalog.—A.P.M. Corp., 252 Hawthorne Ave., Yonkers, N. Y.

Circle 252 on inquiry card.

METALLIC STATIC SEALS for rocket engines, actuators, valves, hose connections, and tube fittings, listed in Eng. Bulletin No. 104.—Cadillac Gage Co., West Coast Div., Costa Mesa, Calif.

Circle 253 on inquiry card.

TEFLON CLAMPS, wedge seals, supports and other solutions for electronic harness problems are contained in new 94-page 8 1/2"x11" engineering design manual. Free on request.—TA Mfg. Corp., 4607 Alger St., Los Angeles 39, Calif.

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